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Final Human Health Risk Assessment

Maunabo Groundwater Contamination Site

Remedial Investigation/Feasibility Study

Maunabo, Puerto Rico

WA No.: 014-RICO-02XF

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CDM Smith

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Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
Cal/EPA	California Environmental Protection Agency
CDM Smith	CDM Federal Programs Corporation
COPC	chemicals of potential concern
CSM	conceptual site model
CTE	central tendency exposure
DCE	dichloroethene
4,4'-DDE	p,p'-dichlorodiphenyldichloroethylene
4,4'-DDT	p,p'-dichlorodiphenyltrichloroethane
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
FS	Feasibility Study
HHRA	human health risk assessment
HQ	hazard quotient
IRIS	Integrated Risk Information System
IUR	inhalation unit risk
MCL	Maximum Contaminant Level
MTBE	methyltertbutylether
NCEA	National Center for Environmental Assessment
NOAEL	no-observed-adverse-effect level
NPL	National Priority List
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PEF	particulate emission factor
PPRTV	Provisional Peer Reviewed Toxicity Values
PRASA	Puerto Rico Aqueduct and Sewer Authority
PRDOH	Puerto Rico Department of Health
PRIDCO	Puerto Rico Industrial Development Corporation
RAC	Remedial Action Contract
RAGS	Risk Assessment Guidance for Superfund
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
RPF	relative potency factor
RSL	Regional Screening Level
SAT2	Site Assessment Team 2
SF	slope factor
the site	Maunabo Groundwater Contamination Site
SVOC	semi-volatile organic compound
TAL	target analyte list
TCE	trichloroethene

TCL	target compound list
TDS	total dissolved solid
TKN	total Kjehldahl nitrogen
TOC	total organic carbon
TSS	total suspended solid
UCL	upper confidence limit
VOC	volatile organic compound

cm	centimeter
cm^2	square centimeter
hr	hour
kg	kilogram
L	liter
m	meter
m^3	cubic meter
mg	milligram
ml	milliliter
µg	microgram

Executive Summary

CDM Federal Programs Corporation (CDM Smith) received Work Assignment No. 014-RICO-02XF under the Remedial Action Contract (RAC) II to perform a Remedial Investigation/Feasibility Study (RI/FS) for the United States Environmental Protection Agency (EPA), Region 2 at the Maunabo Groundwater Contamination site (the site) located in Maunabo, Puerto Rico.

This human health risk assessment (HHRA), as part of the RI/FS, is developed to characterize potential human health risks associated with groundwater in the absence of any remedial action. The HHRA is conducted in accordance with current EPA guidance outlined in *Risk Assessment Guidance for Superfund* (RAGS), Parts A, D, E, and F and other EPA guidance pertinent to human health risk assessments. The HHRA consists of sections describing site background and setting, data evaluation, exposure assessment, toxicity assessment, risk characterization, and summary of risk assessment.

Site Background and Setting

The Maunabo Groundwater Contamination site is located in the municipality of Maunabo, in the southeastern coastal area of Puerto Rico. The site is located within an isolated alluvial river valley, and is surrounded by mountains to the north, east, and west, and the Caribbean Sea to the southeast. The Maunabo River and several intermittent streams are located within the vicinity and flow southeast toward the Caribbean Sea. Groundwater discharge forms the baseflow of the river and also discharges to smaller tributaries and streams (quebradas) such as Quebrada Arenas. Puerto Rico Beverage and the Former Sugar Mill are located to the north and south of the Maunabo #1 supply well and have been investigated as possible sources of contamination.

Maunabo's public water system, known as Maunabo Urbano, consists of four groundwater wells: Maunabo #1, Maunabo #2 (Bordaleza), Maunabo #3 (Calzada), and Maunabo #4 (San Pedro). In March 2002, the Puerto Rico Department of Health (PRDOH) ordered the Puerto Rico Aqueduct and Sewer Authority (PRASA) to close Maunabo #1 due to concentrations of tetrachloroethene (PCE) above the maximum contaminant level (MCL). Rather than close the well, PRASA opted to treat the groundwater with activated carbon treatment tanks due to water supply needs. Detections of PCE in pre-treatment samples from Maunabo #1 exceeded the MCL, but post-treatment samples exhibited PCE at concentrations below the MCL. PRASA has since replaced the tanks with three new tanks. The 2011 monthly data supplied by PRASA show that PCE has been detected in some post-treatment samples, but at levels below the MCL.

In October 2005, EPA's Region 2 Site Assessment Team 2 (SAT 2) collected water samples from each well, and from the distribution water line. In December 2005, SAT 2 conducted an investigation of possible sources of groundwater contamination at five industrial sites around the Maunabo area. Results of the October and December 2005 investigations indicated there was insufficient information to conclusively determine the source(s) of contamination of the drinking water supply well. Subsequently, the Agency for Toxic Substances and Disease Registry (ATSDR) evaluated available data, and conducted a site visit to complete a Public Health Assessment. Results of the Public Health Assessment concluded that the wells exceeded EPA's MCLs for PCE and *cis*-1,2-DCE in the past. However, exceedances were intermittent and did not exceed ATSDR's health based comparison values, and that current and future conditions at the site present no apparent public health hazard. The Maunabo groundwater contamination site was proposed for the National Priority List (NPL) on April 19, 2006 and was listed on September 27, 2006.

Data Evaluation

Previous investigations were conducted by SAT 2 in October and December 2005 to identify possible sources of contamination in Maunabo public water supply wells. CDM Smith, on behalf of EPA, conducted an RI field investigation in January through June 2011. Soil, groundwater, surface water, and sediment samples were collected as part of this investigation. These data are used to adequately characterize contamination at the site to support the RI and the HHRA.

Chemicals of potential concern (COPCs) are identified based on criteria outlined in RAGS, primarily through comparison to risk-based screening levels. Two semi-volatile organic compounds (SVOC) and eight inorganics are identified as COPCs in the surface and subsurface soil at the Former Sugar Mill area. Seven inorganics are identified as COPCs in the surface and subsurface soil at the Puerto Rico Beverage area. Five volatile organic compounds (VOC) and nine inorganics are identified as COPCs in the groundwater. Two VOCs and six inorganics are identified as COPCs in surface water and sediment, respectively, from the Maunabo River.

Exposure Assessment

Potential exposure pathways at the site are defined based on potential source areas, release mechanisms, and current and potential future uses of the site. Potential receptors evaluated in the risk assessment include:

- Current Land-Use Scenario
  - Commercial Industrial Workers at Former Sugar Mill and Puerto Rico Beverage
  - Trespassers at Former Sugar Mill and Puerto Rico Beverage
  - Residents at Former Sugar Mill
  - Recreational Users at Maunabo River
- Future Land-Use Scenario
  - Commercial Industrial Workers at Former Sugar Mill and Puerto Rico Beverage
  - Trespassers at Former Sugar Mill and Puerto Rico Beverage
  - Residents at Former Sugar Mill, Puerto Rico Beverage, and Maunabo River
  - Recreational Users at Maunabo River
  - Construction Workers at Former Sugar Mill and Puerto Rico Beverage

Exposure pathways evaluated for soil include ingestion of and dermal contact with soil, inhalation of particulates from soil by commercial/industrial workers, trespassers, residents, and construction workers. Exposure pathways evaluated for groundwater include ingestion of and dermal contact with groundwater, inhalation of vapor released during showering and bathing, and inhalation of vapor through vapor intrusion by commercial/industrial workers and residents. Exposure pathways evaluated for surface water and sediment include ingestion of and dermal contact by recreational users.

Exposure point concentrations (EPCs) for the COPCs are used in the exposure assessment calculations to estimate potential chemical intake. The EPC is the lower of the upper confidence limit (UCL) on the mean or the maximum detected concentration.

Quantification of exposure includes evaluation of exposure parameters that describe the exposed population (e.g., contact rate, exposure frequency and duration, and body weight). Each exposure parameter in the equation has a range of values. Daily intakes are calculated based on the reasonable maximum exposure (RME) scenario (the highest exposure reasonably expected to occur at a site). The intent is to estimate a conservative exposure case that is still within the range of possible exposures. Central tendency exposure (CTE) assumptions are also developed, when the estimated risks under RME scenario exceed EPA's threshold risk range. CTE scenarios reflect more typical exposures.

Toxicity Assessment

COPCs are quantitatively evaluated on the basis of their noncancer and/or cancer potential. The reference dose (RfD) and reference concentration (RfC) are the toxicity values used to evaluate noncancer health hazards in humans. Inhalation unit risk and slope factor are the toxicity values used to evaluate cancer health effects in humans. These toxicity values are obtained from various sources following the hierarchy order specified by EPA.

Risk Characterization

Risk characterization integrates the exposure and toxicity assessments into quantitative expressions of risks/health effects. To characterize potential noncancer health effects, comparisons are made between estimated intakes of substances and toxicity thresholds. Potential cancer effects are evaluated by calculating probabilities that an individual will develop cancer over a lifetime exposure based on projected intakes and chemical specific dose-response information. In general, EPA recommends target risk values, i.e., cancer risk of 10^{-6} (1 in a million) to 10^{-4} (1 in a 10,000) or noncancer health HI of unity, as threshold values for potential human health impacts (EPA 1989). These target values aid in determining whether additional remedial action is necessary at the site.

Risks for all receptors are estimated using RME assumptions. Risks are also estimated using CTE assumptions when the RME assumptions resulted in risk estimates above EPA's thresholds.

For the current and future land-use scenarios, total estimated cancer risks are within EPA's target range (cancer risk of 1×10^{-6} to 1×10^{-4}) for all receptors under the RME scenario, except residents at both the Former Sugar Mill and Puerto Rico Beverage areas. However, under the CTE scenario, the total cancer risks are within EPA's target range of 1×10^{-6} to 1×10^{-4}.

For the current and future land-use scenarios, total noncancer health hazards are below EPA's target threshold (HI of 1) for all receptors under the RME scenario, except commercial and industrial workers, construction workers, and residents at both the Former Sugar Mill and Puerto Rico Beverage areas. The current and future commercial/industrial workers, construction workers, and residents have noncancer HIs exceeding EPA's threshold of unity under the RME scenario for the kidney, respiratory system, lung, and GI tract. Noncancer health hazards for current and future commercial/industrial workers and construction workers are almost entirely due to the hypothetical use of contaminated groundwater as a potable water supply.

For current and future residents, the potential health hazards to the kidney are results of exposure of *cis*-1,2-DCE and vanadium in groundwater, while the potential adverse health effects to the respiratory system are results of exposure to vanadium in soil and groundwater. The potential adverse health effects to the lung and GI tract are mainly results of exposure to arsenic and iron, respectively, in both soil and groundwater. Under the CTE scenario, the HIs still exceed EPA's threshold of unity for the same target organs/effects, except lung and GI tract, affected under the RME.

Current and future commercial/industrial workers and residents may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. However, vapor intrusion is currently not a concern because the existing structures are not near the COPC concentrations which exceed the screening levels and no detections of COPCs were above the screening levels at the top of the water table.

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Section 1
Introduction

CDM Federal Programs Corporation (CDM Smith) received Work Assignment No. 014-RICO-02XF under the Remedial Action Contract (RAC) II to perform a Remedial Investigation/Feasibility Study (RI/FS) for the United States Environmental Protection Agency (EPA), Region 2 at the Maunabo Groundwater Contamination site (the site) located in Maunabo, Puerto Rico.

This human health risk assessment (HHRA), as part of the RI/FS, is developed to characterize potential human health risks associated with the site in the absence of any remedial action. This HHRA identifies the potential exposure pathways by which populations may be exposed. Exposure pathways are identified based on considerations of the sources and locations of contaminants related to the site, the likely environmental fate of the contaminants, and the location and activities of the potentially exposed populations. The HHRA describes exposure points and routes of exposure for each exposure pathway, as well as underlying assumptions regarding receptor characteristics and behavior (e.g., body weight, ingestion rate, exposure frequency). The HHRA also identifies chemicals of potential concern (COPCs) for each environmental medium, exposure point concentrations (EPCs) and toxicity values of COPCs. Finally, the HHRA characterizes potential cancer risks and noncancer health hazards associated with each complete exposure pathway.

1.1 Overview

To prepare this HHRA, CDM Smith reviewed the available information pertaining to the site. Potential exposure pathways, exposure routes, and potentially exposed populations under current and future land-use scenarios are identified. Exposure parameters and daily intakes for exposure scenarios that are quantified and toxicity values for COPCs are presented. The exposure pathways and receptors, exposure parameters, daily intakes, and toxicity values are presented in tabular form in accordance with the standard tables in *Risk Assessment Guidance for Superfund (RAGS) Part D* (EPA 2001).

This HHRA is developed in accordance with the following EPA guidance documents:

- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A* (EPA 1989)
- *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (EPA 1991)
- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part D* (EPA 2001)
- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA 2004)
- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment* (EPA 2009)
- EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (EPA 2011a)
- *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (EPA 2002)

- ProUCL Version 4.1 User Guide (Draft) and ProUCL Version 4.1.00 Technical Guide (Draft) (EPA 2010a and 2010b)
- Integrated Risk Information System (IRIS) (on-line database of toxicity information) (EPA 2011b)
- Provisional Peer Reviewed Toxicity Values (PPRTV) (on-line database of toxicity values derived for use in the Superfund program when such values are not available from IRIS)

1.2 Report Organization

This HHRA is composed of six sections, with tables and figures presented at the end of the text. The organization of the report and the contents of each section are described below.

Section 1 Introduction – provides an overview of the objectives and organization of the HHRA

Section 2 Site Background and Setting – briefly describes the site location and description, site history, site geology and hydrogeology, demography, and land use

Section 3 Data Evaluation – presents sample collection and analysis at various media, analytical data summary, data usability, and identification of COPCs

Section 4 Exposure Assessment – presents a conceptual site model (CSM) and identifies potential exposure pathways and potential receptor populations under both current and future land-use scenarios. In addition, methods for calculating EPCs are also presented in this section.

Section 5 Toxicity Assessment – discusses the relevant toxicity information on the identified COPCs

Section 6 Risk Characterization – integrates the toxicity and exposure assessments into quantitative and qualitative expressions of risk, and discusses uncertainties associated with the risk estimates

Section 7 Summary of Risk Assessment – summarizes the results of the risk assessment and presents conclusions based on the results

Section 8 References – lists references cited in this report

Section 2
Site Background and Setting

This section describes the site location and description, site history, geology and hydrogeology, surface water bodies, demography, and land use. This information is used to develop site-specific information on exposure pathways and receptors associated with the site.

2.1 Site Location and Description

The Maunabo Groundwater Contamination site is located in the municipality of Maunabo, in the southeastern coastal area of Puerto Rico (Figure 2-1). The site is located within an isolated alluvial river valley, and is surrounded by mountains to the north, east, and west, and the Caribbean Sea to the southeast. The Maunabo River and several intermittent streams are located within the vicinity and flow southeast toward the Caribbean Sea. Groundwater discharge forms the baseflow of the river and also discharges to smaller tributaries and streams (quebradas) such as Quebrada Arenas. Puerto Rico Beverage and the Former Sugar Mill are located to the north and south of the Maunabo #1 supply well and have been investigated as possible sources of contamination (Figure 2-2).

2.2 Site History

Maunabo's public water system, known as Maunabo Urbano, consists of four groundwater wells: Maunabo #1, Maunabo #2 (Bordaleza), Maunabo #3 (Calzada), and Maunabo #4 (San Pedro). In March 2002, the Puerto Rico Department of Health (PRDOH) ordered the Puerto Rico Aqueduct and Sewer Authority (PRASA) to close Maunabo #1 due to concentrations of tetrachloroethene (PCE) above the maximum contaminant level (MCL). Rather than close the well, PRASA opted to treat the groundwater with activated carbon treatment tanks due to water supply needs. Detections of PCE in pre-treatment samples from Maunabo #1 exceeded the MCL, but PCE was detected in post-treatment samples at levels below the MCL. PRASA has since replaced the tanks with three new tanks. The 2011 monthly data supplied by PRASA show that PCE has been detected in some post-treatment samples, but at levels below the MCL.

In October 2005, EPA's Region 2 Site Assessment Team 2 (SAT 2) collected water samples from each well, and from the distribution water line. Results indicated the presence of PCE, *cis*-1,2-dichloroethene (DCE), and methyltertbutylether (MTBE) in Maunabo #1, and in post treatment samples along the distribution line at levels below their respective MCLs. In addition, 1,1-DCE was also detected in Maunabo #4 at levels below its MCL.

In December 2005, SAT 2 conducted an investigation of possible sources of groundwater contamination at five industrial sites around the Maunabo area. Facilities investigated included the former Maunabo Municipal Solid Waste Landfill, PRASA's Wastewater Treatment Plant, El Negro Auto Body/Parts shop, Total Gas Station, Esso Gas Station, and five light industrial facilities operating under the auspices of the Puerto Rico Industrial Development Corporation (PRIDCO) (Figure 2-2).

Results of the October and December 2005 investigations indicated there was insufficient information to conclusively determine the source(s) of contamination of the drinking water supply well. Subsequently, the Agency for Toxic Substances and Disease Registry (ATSDR) evaluated available data, and conducted a site visit to complete a Public Health Assessment. Results of the Public Health Assessment concluded that the wells exceeded EPA's MCLs for PCE and *cis*-1,2-DCE in the past. However, exceedances were intermittent and did not exceed ATSDR's health based comparison values, and that current and future conditions at the site present no

apparent public health hazard. The Maunabo groundwater contamination site was proposed for the National Priority List (NPL) on April 19, 2006 and was listed on September 27, 2006.

2.3 Site Geology and Hydrogeology

This section provides a brief summary of the lithologic and hydrogeologic characteristics of the site and immediate area. A more detailed description of site geology and hydrogeology can be found in the RI report.

2.3.1 Site Geology

The Maunabo site is located within an alluvial valley surrounded by hills composed of igneous plutonic rocks. The two strata encountered at the site are the Quaternary-age alluvium deposits and the underlying Late Cretaceous-age igneous plutonic rocks mapped as the San Lorenzo Batholith (Rogers *et al.* 1979). Tonalite outcrops of the Punta Guayanes Complex are located southwest and southeast of the site. Other units near the site consist of metavolcanic rocks to the southwest and small outcrops of metamorphic amphibole hornfels to the west and southeast of the site. The units expected to be found beneath and adjacent to the site are described below.

Quaternary Alluvium Deposits

The Quaternary alluvium deposits consist of unconsolidated silt, clay, sand, and gravel and underlie the Maunabo River valley. The lithology varies widely with numerous discontinuous lenses of clay, silt, and sand. The thickest and most permeable deposits are located within the buried ancestral bedrock valleys and can be up to 200 feet thick (Adolphson *et al.* 1977).

San Lorenzo Batholith

The San Lorenzo Batholith, covering an area of 200 square miles, is one of the most geologically prominent features in southeastern Puerto Rico. The batholith, formed during the Late Cretaceous Age, is composed of three major units, which in chronological order (oldest to youngest) include diorite and gabbro, the San Lorenzo granodiorite and tonalite, and the Punta Guayenes plutonic complex. The Punta Guayenes complex ranges from tonalite to quartz monzanite and is generally concentrated in the outer portion of the batholith (Rogers *et al.* 1979).

2.3.2 Site Hydrogeology

Groundwater is most abundant in the shallow unconfined alluvial aquifer of the Maunabo River valley. The underlying igneous plutonic bedrock yields generally small to moderate quantities of water. Groundwater flow within the alluvium was determined to be at an oblique angle toward the river in the direction of river flow (Adolphson *et al.* 1977).

2.4 Demography and Land Use

The Maunabo site is located within the Maunabo Municipality in southeastern Puerto Rico. The Maunabo Municipality is comprised of 21 square miles with a population of 12,225 and a population density of 582 people per square mile (U.S. Census 2010). The primary land use in the vicinity of the site is agricultural with some residential, commercial, and light industrial development.

Section 3
Data Evaluation

Samples of environmental media, including soil, groundwater, surface water, and sediment, were collected in order to characterize the nature and extent of contamination from the site. The data evaluation step consists of reviewing and evaluating available data. Data evaluation allows for the identification of COPCs. The following subsections describe sample collection and analysis, data usability and the suitability of data for risk assessment purposes, analytical data summary, and the approach used to identify COPCs.

3.1 Sample Collection and Analysis

Previous investigations were conducted by SAT 2 in October and December 2005 to identify possible sources of contamination in Maunabo public water supply wells. CDM Smith, on behalf of EPA, conducted an RI field investigation in January through June 2011. The investigation focused on the nature and extent of groundwater contamination, and identification of potential source areas to define the hydrogeologic framework. Soil, groundwater, surface water, and sediment samples were collected as part of this investigation. Appendix A includes tables listing the samples used in the risk assessment.

3.1.1 Soil Sampling

Surface and subsurface soil samples were collected from the Puerto Rico Beverage and the Former Sugar Mill area because they are potential source areas. Elevated levels of *cis*-1,2-DCE were detected in groundwater screening samples near the Puerto Rico Beverage facility and elevated levels of PCE were detected in groundwater screening samples in the vicinity of the Former Sugar Mill area. A third potential source area, upgradient of Maunabo #4 where elevated levels of 1,1-DCE were detected, was also proposed for soil sampling. However, no potential sources were identified for this area during field reconnaissance; therefore, no soil samples were collected from this area. Other potential source areas, such as the gas station and the dry cleaner, were not targeted because groundwater screening sample results downgradient from these areas showed no site related contaminants.

Surface and subsurface soil samples were collected from six locations in the Former Sugar Mill and Puerto Rico Beverage areas (Figure 3-1). Six surface soil samples (0 to 2 feet below the ground surface [bgs]) were collected from each of the six soil boring locations at the Puerto Rico Beverage and Former Sugar Mill areas. Twenty-four and 20 subsurface soil samples were collected from the Former Sugar Mill and Puerto Rico Beverage areas, respectively. Subsurface soil samples were collected at 4-foot intervals from 2 feet bgs to the groundwater table at approximately 12 feet bgs. One sample was collected from the 2 to 4 feet interval and one sample per four feet intervals thereafter (4 to 8 and 8 to 12 feet). Soil samples were analyzed for the full target compound list (TCL) parameters, including pesticides/polychlorinated biphenyls (PCBs), target analyte list (TAL) metals, grain size (one-half of the samples), pH, and total organic carbon (TOC).

3.1.2 Groundwater Sampling

Two rounds of groundwater samples were collected from 16 monitoring wells, including 3 background monitoring wells, installed during the RI and 4 Maunabo supply wells (Figure 3-2). A total of 35 groundwater samples were collected and analyzed for trace-level volatile organic compounds (VOCs), TCL semi-volatile organic compounds (SVOCs), pesticides/PCBs, TAL metals, cyanide, chloride, methane, ethane, ethene, nitrate/nitrite, sulfate, sulfide, TOC, total suspended solid (TSS), total dissolved solid (TDS), ammonia, alkalinity, hardness, and total Kjehldahl nitrogen (TKN).

3.1.3 Surface Water and Sediment Sampling

Surface water and sediment samples were collected at seven co-located locations in the Maunabo River (Figure 3-3). One sample (SW/SD-01) was collected in the Maunabo River upstream of the site to provide background information. Surface water samples were analyzed for trace-level VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, cyanide, hardness, alkalinity, ammonia, nitrate/nitrite, TKN, sulfate, sulfide, chloride, TOC, TDS, and TSS. Sediment samples were analyzed for full TCL parameters including pesticides/PCBs, TAL metals, grain size, pH, and TOC.

3.2 Data Usability

As part of the RI sampling program, field duplicates, matrix spike/matrix spike duplicates, and trip and rinsate blanks were collected and submitted for analyses. These samples provide information on analytical variability and error, the overall performance of the field sampling effort, and the uncertainty surrounding the analytical results. Appendix E in the HHRA presents the usability of the data. Field duplicate samples provide an indication of analytical variability and error. Rinsate blanks are indicators of equipment cleanliness and the effectiveness of equipment decontamination procedures. Trip blanks are used to assess whether cross contamination of samples has occurred during container shipment and storage. Analytical results obtained from field duplicates are used for quality assurance/quality control purposes and are not included in the datasets for risk evaluation.

A goal of 90 percent completeness was established. For groundwater, 87 analytical results were rejected out of 23,857 total results, for a completeness value of 99.64 percent. For surface water and sediment, 7 and 9 analytical results were rejected out of 1,280 and 1,267 total results, for a completeness value of 99.50 percent for surface water and 99.29 percent for sediment. Finally, for soil, 46 analytical results were rejected out of 7,964 total results, for a completeness value of 99.42 percent. Completeness results, therefore, met the project goal.

Generally, data from the RI field investigation were determined to be suitable for risk assessment purposes as defined in the data quality objectives in the Quality Assurance Project Plan (CDM Smith 2010). Rejected data, as indicated by an “R” qualifier, are not used for any reporting purpose or during the risk assessment evaluation.

3.3 Summary of Analytical Results

The evaluation and summary of analytical results are based on those chemicals that were reported at concentrations higher than the reporting limit in one or more samples. Statistical summaries, comprising the minimum and maximum detected concentrations and detection frequency for chemicals, are presented by medium in Tables B-2.1a through B-2.5 in Appendix B. Analytical data results are summarized below.

3.3.1 Soil

3.3.1.1 Former Sugar Mill

Surface Soil

SVOCs, pesticides, and metals were detected in surface soil at the Former Sugar Mill area (Table B-2.1a in Appendix B).

SVOCs: Seventeen SVOCs were detected in the surface soil. Carcinogenic polycyclic aromatic hydrocarbons (PAHs), including benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and dibenz(a,h)anthracene, were detected in at least 2 of the 6 surface soil samples.

Pesticides: Seven pesticides were detected in the surface soil. Dieldrin was the most frequently detected pesticide (2 of 6 samples).

Inorganics: Twenty-two metals were detected in the surface soil. All metals were detected in all of the surface soil samples, with the exception of antimony and silver.

Subsurface Soil
VOCs, SVOCs, pesticides, and metals were detected in subsurface soil at the Former Sugar Mill area (Table B-2.2a in Appendix B).

VOCs: Two VOCs were detected in the subsurface soil. Acetone and 2-butanone were detected in 6 and 2 of the 24 subsurface soil samples, respectively.

SVOCs: Nineteen SVOCs were detected in the subsurface soil. Carcinogenic PAHs were detected in at least 3 of the 24 subsurface soil samples.

Pesticides: Seven pesticides were detected in the subsurface soil. p,p'-dichlorodiphenyltrichloroethane (4,4'-DDT) and dieldrin were the two most frequently detected pesticides (3 of 24 samples).

Inorganics: Twenty-three metals were detected in the subsurface soil. Aluminum, barium, calcium, chromium, cobalt, copper, iron, magnesium, mercury, nickel, potassium, sodium, vanadium, and zinc were detected in all subsurface soil samples.

3.3.1.2 Puerto Rico Beverage

Surface Soil
VOCs, SVOCs, pesticides, and metals were detected in surface soil at the Puerto Rico Beverage area (Table B-2.1b in Appendix B).

VOCs: Two VOCs were detected in the surface soil. Acetone and 2-butanone were detected in 1 of the 6 surface soil samples.

SVOCs: Eleven SVOCs were infrequently detected in the surface soil. Butylbenzylphthalate was the most frequently detected SVOC (3 of 6 samples).

Pesticides: Six pesticides were detected in the surface soil. p,p'-dichlorodiphenyldichloroethylene (4,4'-DDE), gamma-chlordane, and heptachlor epoxide were the three most frequently detected pesticides (2 of 6 samples).

Inorganics: Twenty-one metals were detected in the surface soil. All metals were detected in all of the surface soil samples, except antimony, arsenic, cadmium, cyanide, and lead.

Subsurface Soil
VOCs, SVOCs, pesticides, and metals were detected in subsurface soil at the Puerto Rico Beverage area (Table B-2.2b in Appendix B).

VOCs: Two VOCs were detected in the subsurface soil. Acetone and 2-butanone were detected in 11 and 5 of the 20 subsurface soil samples, respectively.

SVOCs: Eleven SVOCs were detected in the subsurface soil. Butylbenzylphthalate was the most frequently detected SVOCs (3 of 20 samples).

Pesticides: Six pesticides were detected in the subsurface soil. Gamma-chlordane and heptachlor epoxide were the two most frequently detected pesticides (3 of 20 samples).

Inorganics: Twenty-one metals were detected in the subsurface soil. All metals were detected in all of the subsurface soil samples, except antimony, arsenic, cadmium, cyanide, and lead.

3.3.2 Groundwater

VOCs, SVOCs, pesticides, and metals were detected in groundwater at the site (Table B-2.3 in Appendix B).

VOCs: Nineteen VOCs were detected in the groundwater. *cis*-1,2-DCE was detected in 16 of the 35 groundwater samples with a maximum concentration of 300 microgram per liter (µg/L). *trans*-1,2-DCE was detected in 4 of the 35 groundwater samples with a maximum concentration of 13 µg/L. PCE was detected in 9 of the 35 groundwater samples with a maximum concentration of 8.5 J µg/L. Trichloroethene (TCE) was detected in 7 of the 35 groundwater samples with a maximum concentration of 1.9 µg/L. Vinyl chloride was detected in 3 of the 35 groundwater samples with a maximum concentration of 0.73 µg/L.

SVOCs: Five SVOCs were detected in the groundwater. Pentachlorophenol was the most frequently detected SVOC (2 of 34 samples).

Pesticides: Four pesticides were detected in the groundwater. Endosulfan I was the most frequently detected pesticide (2 of 34 samples).

Inorganics: Twenty-one metals were detected in the groundwater. The essential nutrient, calcium, magnesium, potassium, sodium were detected in all of the groundwater samples. Barium and manganese were the most frequently detected metals (31 of 31 samples).

3.3.3 Surface Water

VOCs, SVOCs, and metals were detected in surface water at the site (Table B-2.4 in Appendix B).

VOCs: Three VOCs were detected in the surface water samples. Bromodichloromethane and dibromochloromethane were each detected in 3 of the 6 surface water samples. Bromoform was detected in 2 of 6 surface water samples.

SVOCs: One SVOC, bis(2-ethylhexyl)phthalate, was detected in the surface water.

Inorganics: Ten metals were detected in the surface water. Barium, calcium, manganese, potassium, sodium, and zinc were detected in all of the samples.

3.3.4 Sediment

SVOCs, pesticides, and metals were detected in sediment at site (Table B-2.5 in Appendix B).

SVOCs: One SVOC, bis(2-ethylhexyl)phthalate, was detected in the sediment samples.

Pesticides: Six pesticides were detected in the sediment samples. Methoxychlor was the most frequently detected pesticide (2 of 6 samples).

Inorganics: Fifteen metals were detected in the sediment. All inorganics were detected in all of the sediment samples, except arsenic and lead.

3.4 Identification of Chemicals of Potential Concern

Many chemicals have been detected in soil, groundwater, surface water, and sediment from samples collected at the site. Screening of analytical data is conducted to identify COPCs to be further evaluated in the risk assessment. Screening helps to focus the assessment on chemicals that could pose a human health risk.

The screening levels are based on Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites (EPA 2011a). Residential RSLs for soil are used as screening levels for soil and sediment, while tap water RSLs are used as screening levels for groundwater and surface water. To account for exposure to multiple chemicals, RSLs for chemicals based on noncancer health effects are decreased by a factor of 10 to account for a target hazard quotient (HQ) of 0.1.

The maximum detected concentrations are compared to screening levels to identify COPCs. Chemicals are considered COPCs if the maximum detected concentration exceeds the respective screening level. Group A carcinogens (i.e., known human carcinogen) are retained as COPCs even when they are present at the site at concentrations below their respective screening levels. Calcium, magnesium, potassium, and sodium are essential nutrients and are not evaluated as COPCs in health risk assessments. Detection frequency and chemical toxicity are also considered in the identification of COPCs. If a chemical is detected in 5 percent or less of the samples in a data set having at least 20 samples, then the chemical is only considered a COPC if it is a Group A carcinogen. The decision process for identifying COPCs is provided in Tables B-2.1a through B-2.5 in Appendix B.

Risks from exposure to lead are not quantified following the exposure models for other COPCs. EPA considers lead to be a special case because of the difficulty in identifying the "threshold". Health risks from lead are evaluated based on blood lead concentration, which can be modeled using the Integrated Exposure Uptake Biokinetic Model or the Adult Lead Model. The screening levels for lead for residential and industrial soil are 400 and 800 milligram per kilogram (mg/kg), respectively, based on the OSWER Directive 9355.4-12 (EPA 1994). For groundwater, the screening level of 15 µg/L is based on the Puerto Rico Water Quality Standard and the Federal MCL. The screening process for lead is performed separately in the Lead Worksheet detailed in Table 3-1.

For vapor intrusion, generic screening levels provided by EPA in *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (Subsurface Vapor Intrusion Guidance) (EPA 2002a) are used as screening levels. The vapor intrusion screening levels are based on a cancer risk of 10^{-6} and/or a HQ of 1. For some VOCs, where Federal MCLs are listed as vapor intrusion screening levels, risk-based screening level based on a cancer risk of 10^{-4} is adjusted to a 10^{-6} value (2002a). The vapor intrusion screening process is performed in Table E-1 in Appendix E.

COPCs identified in each medium for further quantitative evaluation in the HHRA are presented in Table 3-2.

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Section 4
Exposure Assessment

As a component of the HHRA, the exposure assessment strives to predict human exposure to COPCs in affected media at the site and in the vicinity. The exposure assessment describes exposure scenarios in which people may come into contact with site-related COPCs, provides equations and parameters to quantify exposure, and summarizes methods for evaluating exposure to lead. Results of the exposure assessment are integrated with chemical-specific toxicity information to characterize potential risks.

4.1 Exposure Pathways

Potential exposure pathways for the site are defined based on current and potential future land uses of the site. Each potential pathway is evaluated considering site-specific conditions to determine if the pathway could be present. The area demography and land use characteristics are taken into consideration when the pathways are developed. If a pathway between the source of contamination and a human receptor could potentially be complete, it is retained for further evaluation.

4.1.1 Conceptual Site Model

Contamination at the site may be linked to previous releases and discharges to the environment. Results of the previous investigations indicated there was insufficient information to conclusively determine the source(s) of contamination of the drinking water supply wells. People living, working or recreating at the site may be exposed to contaminants in soil, groundwater, surface water, and sediment. A CSM, illustrating how chemicals may move from historical release points to locations where human exposure may occur, is developed to provide a roadmap to these possible exposures. The CSM is presented in Figure 4-1 and described in detail in the following sections.

4.1.2 Identification of Exposure Pathways

As defined in the RAGS Part A (EPA 1989), an exposure pathway is composed of the following elements:

- A source and mechanism of chemical release to the environment
- An environmental transport medium (e.g., groundwater) for the released chemical and/or mechanism to transfer the chemical from one medium to another
- A point of potential contact by humans with the contaminated medium
- A route of exposure (i.e., ingestion, inhalation, or dermal contact)

In the risk assessment, pathways are identified for the No Action alternative to evaluate risk if no site remediation occurs. This assessment also assumes that no additional restrictions to site access or use exist. The goal of this evaluation is to establish whether it is feasible for individuals to engage in activities resulting in exposure to site-related contaminants.

Based on the RI, contamination was detected in soil, groundwater, surface water, and sediment at the site. There are three general routes through which individuals could potentially be exposed to chemical contamination in these media: ingestion, inhalation, and dermal contact. A receptor may get small amounts of soil on his hands and subsequently transfer some of this soil to his mouth during common hand-to-mouth

activity. Exposure would occur when this soil is swallowed and some contaminants in soil are absorbed in the gastrointestinal tract.

The following sections describe the potential exposure pathways and receptors under both current and potential future land-use conditions. An identified pathway does not imply that exposure is actually occurring, only that the potential exists for the pathway to be complete.

4.1.2.1 Soil Exposure Pathways

Previous sampling and continued monitoring at the site documented groundwater contamination at the site. However, these chemicals have not been detected in soil at the site. People working, visiting, or living at the site could be exposed to contaminants through incidental ingestion of soil, dermal contact with soil, and inhalation of particulates and volatiles released from soil. Additionally, residents may ingest dust that has settled onto objects, surfaces, floors, and carpeting in their homes.

4.1.2.2 Groundwater Exposure Pathways

Previous sampling and continued monitoring at the site documented groundwater contamination. The site is currently supplied by the Maunabo public water system; no private wells have been identified within the plume area. Current and future residents and commercial/industrial workers may be potentially exposed to groundwater via ingestion of and dermal contact with groundwater, and inhalation of chemical vapor while showering/bathing. In addition, current and future residents and commercial/industrial workers may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. Site groundwater concentrations are compared to the target groundwater concentrations from the 2002 EPA Subsurface Vapor Intrusion Guidance, and the results are presented in Section 6 of this HHRA.

4.1.2.3 Surface Water and Sediment Exposure Pathways

Contaminants at the site may eventually be transported to the Maunabo River via surface runoff, erosion, deposition, and overland flow. Surface water and sediment of the Maunabo River may potentially be impacted. People visiting the river may be exposed to contaminants in surface water and sediment. Routes of exposure include incidental ingestion of and dermal contact with surface water and sediment. In addition, the Maunabo River is classified as Class SD water which is considered a potential potable drinking water source. Although currently residents are using public supply water, in the future, surface water from the Maunabo River could be used as a potable drinking water supply. Residents may be exposed to contaminants in surface water through ingestion of and dermal contact with groundwater and inhalation of vapor while showering /bathing.

4.2 Characterization of Potentially Exposed Populations

The site is currently zoned for residential and commercial/industrial use. The site is currently connected to the public water supply. The Maunabo River may be visited as a recreational area. Based on current and future land uses, exposed populations include or may include at some later date, commercial/industrial workers, trespassers, residents, recreational users, and construction workers. Not all of these populations are expected to be present in all of the areas. The following subsections detail the potential exposure pathways identified for each potentially exposed population. Appendix A includes tables listing the samples used to evaluate each receptors exposure.

4.2.1 Current Receptors

4.2.1.1 Commercial/Industrial Workers

Current commercial/industrial workers at the site may come in contact with contaminants in surface soil through incidental ingestion of and dermal contact with soil, and inhalation of particulates and volatiles released from surface soil. Currently, groundwater at the site is used as drinking water through the Maunabo public water system. To be conservative, workers are assumed to be exposed to groundwater via potable uses through ingestion of and dermal contact with groundwater, and inhalation of VOCs in groundwater while showering at work. In addition, commercial/industrial workers may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. Commercial/industrial workers are evaluated using default parameters recommended by EPA as described in Section 4.5.

4.2.1.2 Trespassers

Trespassers could gain access to most or all areas of the site. When trespassing, these individuals may be exposed to contaminants in surface soil through incidental ingestion of and dermal contact with soil, and inhalation of particulates and volatiles released from surface soil. Adolescent trespassers (7 to 12 years old) are evaluated using default parameters recommended by EPA as described in Section 4.5.

4.2.1.3 Residents

Current residents in the Former Sugar Mill area may come into contact with contaminants through incidental ingestion of soil, dermal contact with soil, and inhalation of particulates and volatiles released from surface soil. Additionally, all residents are connected to the Maunabo public water supply system; thus, current residents are exposed to groundwater through potable water uses. Residents may come into contact with contaminants through ingestion of and dermal contact with groundwater, and inhalation of VOCs in groundwater while bathing or showering. In addition, current residents may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. Current residents are evaluated using default parameters recommended by EPA as described in Section 4.5.

4.2.1.4 Recreational Users

Recreational users who visit the Maunabo River may come into contact with contaminants in surface water and sediment from wading or playing in the river. Routes of exposure may include incidental ingestion of and dermal contact with surface water and sediment. Adolescents (7 to 12 years old) are expected to be present more frequently without adult supervision. Adolescent recreational users are selected as potential receptors. Exposure parameters for adolescent recreational users are described in Section 4.5.

4.2.2 Future Receptors

4.2.2.1 Commercial/Industrial Workers

Similar to current commercial/industrial workers, future workers may come into contact with contaminants in surface soil through incidental ingestion of and dermal contact with soil, and inhalation of particulates and volatiles released from surface soil. Future workers could also be exposed to groundwater via potable uses through ingestion of and dermal contact with groundwater, and inhalation of VOCs in groundwater while showering at work. In addition, future commercial/industrial workers may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. Future commercial/industrial workers are evaluated using default parameters recommended by EPA as described in Section 4.5.

4.2.2.2 Trespassers

Trespassers could gain access to most or all areas of the site. When trespassing, these individuals may be exposed to contaminants in surface soil through incidental ingestion of and dermal contact with soil, and inhalation of particulates and volatiles released from surface soil. Adolescent trespassers (7 to 12 years old) are evaluated using default parameters recommended by EPA as described in Section 4.5.

4.2.2.3 Residents

The Puerto Rico Beverage area may be developed into residential properties in the future. Residents in both the Former Sugar Mill and Puerto Rico Beverage areas may come into contact with contaminants through incidental ingestion of soil, dermal contact with soil, and inhalation of particulates and volatiles released from surface soil. Additionally, all residents are connected to the Maunabo public water supply system; thus, residents are exposed to groundwater through potable water uses. Residents may come into contact with contaminants through ingestion of and dermal contact with groundwater, and inhalation of VOCs in groundwater while bathing or showering. In addition, future residents may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. Residents who use the Maunabo River as potable water uses may come into contact with contaminants through ingestion of and dermal contact with surface water, and inhalation of VOCs in groundwater while bathing or showering. Future residents are evaluated using default parameters recommended by EPA as described in Section 4.5.

4.2.2.4 Recreational Users

Recreational users who visit the Maunabo River may come into contact with contaminants in surface water and sediment from wading or playing in the river. Routes of exposure may include incidental ingestion of and dermal contact with surface water and sediment. Adolescents (7 to 12 years old) are expected to be present more frequently without adult supervision. Adolescent recreational users are selected as potential receptors. Exposure parameters for adolescent recreational users are described in Section 4.5.

4.2.2.5 Construction Workers

If construction takes place at the site in the future, construction workers could have short-term, high intensity exposure to contaminants in surface and subsurface soil via incidental ingestion of and dermal contact with soil, and inhalation of particulates and volatiles released from surface and subsurface soil. Future construction workers are evaluated using default parameters recommended by EPA as described in Section 4.5.

4.3 Summary of Exposure Pathways and Receptors

The following exposure pathways for each receptor at Puerto Rico Beverage and Former Sugar Mill under current and future land-use scenarios are considered to be potentially complete and are evaluated as part of the assessment of exposure to contaminants at the site. A summary of these exposure pathways is illustrated in Figure 4-1 and presented in Table 4-1.

CURRENT LAND-USE SCENARIO

The Site

- Commercial/Industrial Worker
  - Groundwater
    - *Ingestion*
    - *Dermal contact*
    - *Inhalation of volatiles during showering*
    - *Inhalation of volatiles through vapor intrusion*

- Resident
  - Groundwater
    - *Ingestion*
    - *Dermal contact*
    - *Inhalation of volatiles during showering or bathing*
    - *Inhalation of volatiles through vapor intrusion*

Puerto Rico Beverage

- Commercial/Industrial Worker
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Trespasser (Adolescent [7-12 years])
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

Former Sugar Mill

- Commercial/Industrial Worker
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Trespasser (Adolescent [7-12 years])
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Resident
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

Maunabo River

- Recreational User (Adolescents [7 to 12 years old])
  - Surface Water
    - *Incidental ingestion*
    - *Dermal contact*
  - Sediment
    - *Incidental ingestion*
    - *Dermal contact*

FUTURE LAND-USE SCENARIO

The Site

- Commercial/Industrial Worker
  - Groundwater
    - *Ingestion*
    - *Dermal contact*
    - *Inhalation of volatiles during showering*
    - *Inhalation of volatiles through vapor intrusion*

- Resident
  - Groundwater
    - *Ingestion*
    - *Dermal contact*
    - *Inhalation of volatiles during showering or bathing*
    - *Inhalation of volatiles through vapor intrusion*

Puerto Rico Beverage

- Commercial/Industrial Worker
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Trespasser (Adolescent [7-12 years])
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Resident
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Construction Worker
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

Former Sugar Mill

- Commercial/Industrial Worker
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Trespasser (Adolescent [7-12 years])
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Resident
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

- Construction Worker
  - Surface Soil
    - *Incidental ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

Maunabo River

- Recreational User (adolescents [7 to 12 years old])
  - Surface Water
    - *Incidental ingestion*
    - *Dermal contact*
  - Sediment
    - *Incidental ingestion*
    - *Dermal contact*

- Resident
  - Surface Water
    - *Ingestion*
    - *Dermal contact*
    - *Inhalation of particulates and volatiles*

4.4 Calculation of Exposure Point Concentrations

This section presents the methodology that was employed to calculate the EPCs for the COPCs for each medium including ambient air from soil particulates.

4.4.1 Exposure Point Concentrations of Samples Collected

For each data set (representing a single chemical in soil, groundwater, surface water, and sediment) with at least 5 samples with 4 detected values, a 95 percent (or higher) upper confidence limit (UCL) on the arithmetic mean concentration was calculated and compared to the maximum detected concentration for that chemical. The lower value of the UCL and the maximum detected value is selected as the EPC, as recommended by EPA (1992). UCLs are not calculated for data sets with fewer than four detected concentrations. In such cases, maximum concentrations are used as the EPCs.

Several statistical methods can be used to estimate the UCL of a data set, depending upon the data distribution. Therefore, two key steps are required to estimate the UCL of a data set.

- Determine the distribution of the data (i.e., normal, lognormal, gamma, or neither)

- Compute the UCL using the appropriate procedure for the data distribution

In this assessment, both steps were performed with the ProUCL statistical software (EPA 2010b). The ProUCL program tests the normal, lognormal, gamma, and non-parametric distributions of each data set and the UCLs are calculated with the statistical procedures recommended by EPA, based on the findings of Singh, Singh, and Engelhardt (1997, 1999) (EPA 2010b). ProUCL computes the UCL using 5 parametric and 10 non-parametric methods, depending on the distribution.

- For normal distributions, the Student's t-statistic is used to calculate the UCL.
- For lognormal distributions, one of four different computation methods is used to calculate the UCL depending on the skewness of the data (as indicated by the standard deviation of the log-transformed data) and the sample size.
- For gamma distributions, one of two computation methods is used to calculate the UCL based on a "k value," which is the shape parameter of a gamma distribution. For values of $k \geq 0.1$, the exposure point concentration term is computed using an adjusted gamma UCL of the mean (when $0.1 \leq k \leq 0.5$) or an approximate gamma UCL of the mean (when $k > 0.5$). For values of $k < 0.1$, a UCL is obtained using either the bootstrap-t method or Hall's bootstrap method when the sample size is small (less than 15), or the approximate gamma for larger datasets.
- For data sets that do not fit a normal, a lognormal, or gamma distribution, the ProUCL program calculates and recommends a UCL from 1 of the 10 non-parametric methods (EPA 2010b).

Tables B 3.1a through B 3.5 in Appendix B present the EPCs for each COPC in each medium. As noted previously, the EPC is the lower value of the UCL and the maximum detected value. ProUCL outputs for COPCs are presented in Appendix C.

4.4.2 Exposure Concentrations for Inhalation

In accordance with EPA *Risk Assessment Guidance for Superfund, Part F, Supplemental Guidance for Inhalation Exposure* (EPA 2009), inhalation exposure could be categorized as acute, subchronic, and chronic exposures, based on exposure duration and exposure pattern. Exposure concentrations for inhalation exposure are calculated based on the EPA 2009 RAGS Part F Guidance.

Chronic exposure is generally used for continuous or near-continuous inhalation exposures that occur for seven years or more. Subchronic exposure refers to repeated exposures for more than 30 days up to 7 years. Acute exposure includes exposures lasting 24 hours or less or intermittent exposures that occur at a series of short periods (e.g., 4 hours) separated by several days of no exposure. Based on the exposure duration and exposure pattern, chronic exposure applies to commercial/industrial workers, construction workers, and residents. Acute exposure applies to trespassers.

4.4.3 Indoor Air Exposure Point Concentrations Using the Shower Model

Modeling is required to estimate the indoor air concentrations of VOCs from groundwater while showering. In this scenario, receptors are assumed to inhale VOCs while showering and during time spent in the bathroom after showering. Dermal absorption of volatilized VOCs is assumed to be negligible due to low dermal permeabilities. Methodologies for estimating exposure to VOCs in domestic water supplies from the inhalation exposure route are based on a shower model developed by Schaum *et al.* (1994).

The shower model treats the bathroom as one compartment and yields an air concentration averaged over the time of the actual shower and the time spent in the bathroom after the shower. The model was derived by

assuming that the chemical contaminant volatilizes at a constant rate, instantly mixes uniformly with the bathroom air, and that ventilation with clean air does not occur. This implies that the chemical concentration in the air increases linearly from zero to a maximum at the end of the shower, and then remains constant during the time an individual spends in the bathroom immediately after showering.

The air concentration is estimated using the water concentration. The water concentration is a site-specific value that refers to the concentration of a chemical in water as it enters the shower. The UCL value or the maximum detected value is utilized as the water concentration (i.e., the EPC listed in Table B-3.3 in Appendix B). Chemical-specific fraction volatilized values are calculated from these chemical properties using the equation provided by Schaum *et al.* (1994) (see Tables D-1 and D-2 in Appendix D).

The water flow rate of 1,000 liter (L)/hour is assumed in the model for the reasonable maximum exposure (RME) scenario and 500 L/hour for the central tendency exposure (CTE) scenario (Schaum *et al.* 1994). The bathroom volume of 6 cubic meters (m^3) is assumed in the model for the RME scenario and 16 m^3 for the CTE scenario (Schaum *et al.* 1994). The time spent in showering is 0.25 and 0.45 hour for adults and young children (0 to 6 years), respectively, under the RME scenario and 0.1 and 0.14 hour under the CTE scenario (EPA 2004). The time spent in the bathroom after showering is assumed to be 0.33 and 0.55 hour for adults and young children, respectively, under the RME scenario and 0.15 and 0.19 hour under the CTE scenario (EPA 2004). Exposure point air concentrations from the shower model are presented in Tables D-3 and D-4 in Appendix D.

4.5 Exposure Parameter Assumptions

Exposure parameters for each scenario are primarily taken from EPA documents (EPA 1989, 1991, 1997, 2002b, 2004, and 2009) and are consistent with EPA Region 2's approach. EPA's standard default assumptions (EPA 1991) or site-specific values are used. Otherwise values from the most recent guidance available are used unless EPA Region 2 has a known preference for a specific value. RME and CTE parameters used in the risk assessment are provided in Tables B-4.1 through B-4.5 in Appendix B.

4.5.1 Commercial/Industrial Workers

Commercial/industrial workers are assumed to be exposed to contaminants in surface soil and groundwater for 250 days per year for the RME scenario (EPA 2004) and 219 days for the CTE scenario (EPA 2004). The exposure duration for workers is 25 years for the RME scenario and 9 years for the CTE scenario (EPA 2004). The exposure time for outdoor workers is 8 hours per day for the RME scenario and 4 hours per day for the CTE scenario. A life expectancy of 70 years (EPA 1989) is used as the averaging time for exposure to carcinogenic contaminants. The averaging time for noncancer effects is equal to the exposure duration, or 25 years under the RME scenario, and 7 years for the CTE scenario (EPA 1989). A body weight of 70 kilogram (kg) is used for both the RME and CTE scenarios (EPA 2002b).

4.5.1.1 Soil

The incidental soil ingestion rate for workers is assumed to be 100 milligram (mg)/day (EPA 2002b) for the RME scenario and 50 mg/day for the CTE scenario (EPA 1997). For dermal contact with soil, the worker is assumed to wear a short-sleeved shirt, long pants, and shoes; therefore, the exposed skin surface is limited to the head, hands, and forearms. The resulting exposed skin surface area is 3,300 square centimeter (cm^2), the average of the 50th percentile for males and females greater than 18 years of age (EPA 2004). A dermal adherence factor of 0.2 mg/cm^2 is assumed for the RME scenario and 0.02 mg/cm^2 is assumed for the CTE scenario (EPA 2004). The chemical-specific dermal absorption fractions for COPCs are presented in Table B-4.5. A particulate emission factor (PEF) of $1.36x10^9$ m^3/kg is used (EPA 2002b).

4.5.1.2 Groundwater

Commercial/industrial workers are assumed to be exposed to groundwater while at work via ingestion of groundwater as drinking water. Workers are assumed to consume 1 L/day of water for both the RME and CTE scenario (EPA 1991). Inhalation and dermal exposure of workers to groundwater may occur through showering. Shower/bathing duration for adults is assumed to be 0.58 and 0.25 hour under the RME and CTE scenarios, respectively (EPA 2004). For surface area exposed, the estimate of total body surface area is 18,000 cm^2 for adults (EPA 2004). Chemical-specific dermal permeability coefficients for COPCs are presented in Table B-4.5.

4.5.2 Trespassers

Trespassers are assumed to trespass 100 days per year. They are assumed to spend two hours per visit for the RME scenario. One-half of the RME exposure time and frequency are used for the CTE scenario. The RME duration for the trespasser is 6 years for adolescents (7 to 12 years old). A life expectancy of 70 years (EPA 1989) is used as the averaging time for exposure to carcinogenic contaminants. The averaging time for noncancer effects is equal to the exposure duration, or 6 years under both the RME and CTE scenarios. A body weight of 36 kg is used for adolescents (EPA 1997) under both scenarios.

The incidental soil ingestion rate for the trespasser is assumed to be 100 mg/day for adolescents for the RME scenario (EPA 2002b). For the CTE scenario, the soil ingestions rate is assumed to be 50 mg/day for adolescents (EPA 1997). The trespasser is assumed to wear a short-sleeved shirt, shorts, and shoes; therefore, the exposed skin surface is limited to the head, hands, forearms, and lower legs. The exposed skin surface area is 3,600 cm^2 for adolescents (EPA 2004). The adherence factor is 0.07 mg/cm^2 and 0.01 mg/cm^2 is assumed for the RME and CTE scenarios (EPA 2004). The chemical-specific dermal absorption fractions for COPCs are presented in Table B-4.5. A PEF of $1.36x10^9$ m^3/kg is used (EPA 2002b).

4.5.3 Residents

All residents are assumed to be exposed for 24 hours per day, for 350 days per year for both the RME and CTE scenarios (EPA 1991). The total RME duration for residents is assumed to be 30 years (EPA 1991): 24 years as an adult and 6 years as a young child. The CTE duration for adult residents is 9 years, based on the 50th percentile value for years living in the current home (EPA 1997). The CTE duration is assumed to be 6 years for children.

A life expectancy of 70 years (EPA 1989) is used for all receptor groups as the averaging time for exposure to carcinogenic contaminants. The averaging time for noncancer effects is equal to the exposure duration, or 24 years for adults under the RME scenario, 9 years for adults under the CTE scenario, and 6 years for children under both scenarios. A body weight of 70 kg is used for adult residents (EPA 2002b) and 15 kg for children (0 to 6 years old) (EPA 2002b) under both scenarios.

Carcinogenic exposure estimates throughout a lifetime are impacted by age-dependent intake factors. To take into account the difference in daily ingestion rates, body weights, and exposure durations for young children and adults, age-adjusted intake factors are used for carcinogenic exposure estimates (EPA 1991). This is accomplished by using factors for a child for the first 6 years of exposure and adult factors for the remaining 24 years of the exposure period.

4.5.3.1 Soil

The incidental soil ingestion rate for adult residents is assumed to be 100 mg/day (EPA 2002b) for the RME scenario and 50 mg/day for the CTE scenario (EPA 1997). For child residents, the incidental soil ingestion rate is assumed to be 200 mg/day and 100 mg/day for the RME and CTE scenarios, respectively (EPA 2002b). For dermal contact with soil, the adult residents are assumed to wear a short-sleeved shirt, shorts, and shoes; therefore, the exposed skin surface is limited to the head, hands, forearms, and lower legs. The resulting

exposed skin surface area is 5,700 cm^2 (EPA 2004). A dermal adherence factor of 0.07 mg/cm^2 is assumed for RME scenario and 0.01 mg/cm^2 is assumed for the CTE scenario for adult residents (EPA 2004). For dermal contact with soil, the child residents are assumed to wear a short-sleeved shirt, shorts, and no shoes; therefore, the exposed skin surface is limited to the head, hands, forearms, lower legs, and feet. The resulting exposed skin surface area is 2,800 cm^2 (EPA 2004). A dermal adherence factor of 0.2 mg/cm^2 is assumed for the RME scenario and 0.04 mg/cm^2 is assumed for the CTE scenario for child residents (EPA 2004). The chemical-specific dermal absorption fractions for COPCs are presented in Table B-4.5. A PEF of $1.36x10^9$ m^3/kg is used (EPA 2002b).

4.5.3.2 Groundwater

For groundwater ingestion exposure parameters, adult residents are assumed to consume 2 liters of water per day for the RME scenario (EPA 1991) and 1.4 L/day for the CTE scenario, based on a mean water ingestion rate for adults (EPA 1997). A water intake rate of 1 L/day is assumed for child residents based on a 95th percentile drinking water ingestion rate for children 1 to 10 years old (EPA 1997). The CTE drinking water intake rate for children is assumed to be 0.4 L/day, based on a weighted mean drinking water ingestion rate for children between 1 to 10 years of age (EPA 1997).

Inhalation and dermal exposure of residents to groundwater may occur through showering and other household activities. Shower/bathing duration for adults is assumed to be 0.58 and 0.25 hour for the RME and CTE scenarios, respectively (EPA 2004). Children are assumed to spend 1 and 0.33 hour for the RME and CTE scenarios, respective (EPA 2004). For surface area exposed, the estimate of total body surface area is 18,000 cm^2 for adults, based on the average 50th percentiles for males and females (EPA 2004). For child residents, the total surface area is 6,600 cm^2, based on weighted surface area for children between 0 to 6 years of age (EPA 2004). Chemical-specific dermal permeability coefficients for COPCs are presented in Table B-4.5.

4.5.3.3 Surface Water

For surface water ingestion exposure parameters, adult residents are assumed to consume 2 liters of water per day for the RME scenario (EPA 1991) and 1.4 L/day for the CTE scenario, based on a mean water ingestion rate for adults (EPA 1997). A water intake rate of 1 L/day is assumed for child residents based on a 95th percentile drinking water ingestion rate for children 1 to 10 years old (EPA 1997). The CTE drinking water intake rate for children is assumed to be 0.4 L/day, based on a weighted mean drinking water ingestion rate for children between 1 to 10 years of age (EPA 1997).

Inhalation and dermal exposure of residents to surface water as potable water use may occur through showering and other household activities. Shower/bathing duration for adults is assumed to be 0.58 and 0.25 hour for the RME and CTE scenarios, respectively (EPA 2004). Children are assumed to spend 1 and 0.33 hour for the RME and CTE scenarios, respective (EPA 2004). For surface area exposed, the estimate of total body surface area is 18,000 cm^2 for adults, based on the average 50th percentiles for males and females (EPA 2004). For child residents, the total surface area is 6,600 cm^2, based on weighted surface area for children between 0 to 6 years of age (EPA 2004). Chemical-specific dermal permeability coefficients for COPCs are presented in Table B-4.5.

4.5.4 Construction Workers

Exposure pathways evaluated for construction workers at the site include incidental ingestion of and dermal contact with surface and subsurface soil and inhalation of particulates. Construction workers are assumed to be exposed to soils for 8 hours per day, for 5 months (100 workdays) per year for a total duration of 1 year for the RME scenario. A life expectancy of 70 years (EPA 1989) is used as the averaging time for exposure to carcinogenic contaminants. The averaging time for noncancer effects is equal to the exposure duration, or 365 days for construction workers. A body weight of 70 kg is used for construction workers (EPA 2002b).

For the soil ingestion exposure pathway, construction workers are assumed to ingest 330 mg of soil per day (EPA 2002b). For dermal contact with soil, the construction worker is assumed to wear a short-sleeved shirt, long pants, and shoes; therefore, the exposed skin surface is limited to the head, hands, and forearms. The exposed skin surface area for workers is 3,300 cm^2, the average of the 50th percentile for males and females older than 18 years of age (EPA 2004). A dermal adherence factor of 0.3 mg/cm^2 is assumed (EPA 2004), corresponding to the 95^{th} percentile value that has been measured for construction workers. The chemical-specific dermal absorption factors for COPCs are presented in Table B-4.5.

4.5.5 Recreational Users

All recreational users are assumed to spend 175 days per year for the RME scenario and 100 days per year under the CTE scenario (EPA 2012). The exposure time is assumed to be 1 hour per day for both the RME and CTE scenarios. The duration for recreational users is 6 years for adolescents (7 to 12 years old).

A life expectancy of 70 years (EPA 1989) is used for all receptor groups as the averaging time for exposure to carcinogenic contaminants. The averaging time for noncancer effects is equal to the exposure duration, or 6 years. The averaging time for noncancer effects is 12 years for adolescents and 6 years for children under both scenarios. A body weight of 36 kg is used (EPA 1997) under both scenarios.

4.5.5.1 Surface Water

The incidental ingestion rate recommended by EPA (1989) for surface water while swimming is 50 milliliters per day (ml/day). For dermal contact with surface water in a swimming scenario, the recreational user is assumed to have full body contact with surface water. The exposed skin surface area is 11,000 cm^2 for adolescents, based on the weighted average surface area for children aged 7 to 12 years (EPA 2004). This skin surface area value is assumed for both the RME and CTE scenarios.

4.5.5.2 Sediment

Ingestion of sediment is limited to sediment that has been suspended in the water column while swimming and sediment which sticks to the feet, hands, or other body parts. In the absence of an ingestion rate for sediment, exposure assumptions are based on the ingestion rate for soil. The incidental ingestion rate for sediment is, therefore, assumed to be 100 mg/day. One-half of the RME rates are used for the CTE scenario. For dermal contact with sediment, the recreational user is assumed to wear a short-sleeved shirt, shorts, and no shoes; therefore, the exposed skin surface is limited to the head, hands, forearms, lower legs, and feet. The exposed skin surface area is 4,400 cm^2 for adolescent recreational users, the weighted average for children 7 to 12 years of age (EPA 2004). A sediment adherence factor of 0.2 mg/cm^2 is used for both RME and CTE scenarios, based on the geometric mean soil adherence factor for children playing in wet soil (EPA 2004). The chemical-specific dermal absorption fractions for COPCs are presented in Table B-4.5.

Section 5
Toxicity Assessment

Health criteria used in this risk assessment were obtained from a variety of toxicological sources according to a hierarchy established in the OSWER directive 9285.7-53 (EPA 2003). The toxicity value hierarchy is as follows:

- Tier 1—EPA's IRIS
- Tier 2—EPA's PPRTVs: The Office of Research and Development/National Center for Environmental Assessment (NCEA)/Superfund Health Risk Technical Support Center develops PPRTVs on a chemical-specific basis when requested by EPA's Superfund program.
- Tier 3—Other Toxicity Values: Tier 3 includes additional EPA and non-EPA sources of toxicity information, such as the California Environmental Protection Agency (Cal/EPA) and the ATSDR. Priority should be given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer-reviewed.

5.1 Health Effects Criteria for Noncarcinogens

For chemicals that exhibit noncancer (e.g., systemic) effects, many authorities consider organisms to have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the health effect is manifested. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects.

Health criteria for chemicals exhibiting noncancer effects for use in risk assessment are generally EPA-derived reference doses (RfDs) and reference concentrations (RfCs). The RfD or RfC is an estimate of average daily exposure to an individual (including sensitive individuals) that is likely to be without appreciable risk of deleterious effects during a lifetime. The RfD is expressed in units of mg chemical per kg body weight per day (mg/kg-day), while the RfC is expressed in unit of mg chemical per cubic meter of air (mg/m^3).

RfDs and RfCs are usually derived either from human studies involving work-place exposures or from animal studies, and are adjusted using uncertainty factors to ensure that they are unlikely to underestimate the potential for adverse noncancer effects to occur. The uncertainty factors reflect scientific judgment regarding the various types of data used to estimate the RfD/RfC and range between 1 and 10. For example, a factor of 10 may be introduced to account for possible differences in response between humans and animals in prolonged exposure studies. Other factors of 10 may be used to account for variation in susceptibility among individuals in the human population, use of data from a study with less-than-lifetime exposure, and/or use of data from a study that did not identify a no-observed-adverse-effect level (NOAEL).

RfDs and RfCs provide benchmarks against which estimated doses (i.e., those projected from human exposures to various environmental conditions) might be compared. Doses that are significantly higher than the RfD/RfC may indicate an increased potential of hazard from the exposure, while doses that are less than the RfD/RfC are not likely to be associated with adverse health effects. Note that an exceedance of a reference dose or concentration does not predict a specific disease.

5.2 Health Effects Criteria for Carcinogens

For chemicals that exhibit cancer effects, EPA and other scientific authorities recognize that one or more molecular events can evoke changes in a single cell or a small number of cells that can lead to malignancy. This non-threshold theory of carcinogenesis purports that any level of exposure to a carcinogen can result in some finite possibility of causing cancer. Generally, regulatory agencies assume the non-threshold hypothesis for carcinogens in the absence of information concerning the mechanisms of cancer action for the chemical. The slope factor (SF) [in units of $(mg/kg\ body\ weight\text{-}day)^{-1}$] is a number which, when multiplied by the lifetime average daily dose of a potential carcinogen (in mg/kg body weight-day), yields the upper-bound lifetime excess cancer risk associated with exposure at that dose. The SF is developed for exposure through the oral route.

When the units are risk per microgram per cubic meter ($\mu g/m^3$), it is called the inhalation unit risk (IUR). The IUR is the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to a chemical at a concentration of 1 $\mu g/m^3$ in air. Upper-bound is a term used by EPA to reflect the conservative nature of the SFs and IURs—risks estimated using SFs and IURs are considered unlikely to underestimate actual risks and may overestimate risks for a given exposure. Excess lifetime cancer risks are generally expressed in scientific notation and are probabilities. An excess lifetime cancer risk of 1×10^{-6} (one in one million), for example, represents the incremental probability that an individual will develop cancer as a result of exposure to a cancer chemical over a 70-year lifetime under specified exposure conditions.

In practice, SFs and IURs estimates are derived from the results of human epidemiology studies or chronic animal bioassays. The animal studies are conducted for a range of doses, including a high dose, in order to detect possible adverse effects. Since humans are expected to be exposed at lower doses than those used in animal studies, the data are adjusted via mathematical models. The data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response curve. EPA evaluates a range of possible models based on the available data before conducting the extrapolation. The most appropriate model to reflect the data is selected based on an analysis of the data set.

The 95% UCL slope of the dose-response curve, subject to various adjustments and an inter-species scaling factor, is applied to derive the health protective SF and IUR estimate for humans. Dose-response data from human epidemiological studies are fitted to dose-time-response curves. These models provide rough, but reasonable, estimates of the upper limits on lifetime risk. SF and IUR estimates based on human epidemiological data are also derived using health protective assumptions and, as such, they too are considered unlikely to underestimate risks.

Therefore, while the actual risks associated with exposures to potential carcinogens are unlikely to be higher than the risks calculated using SF and IUR estimates, they could be considerably lower. In addition, there are varying degrees of confidence in the weight of evidence for carcinogenicity of a given chemical. EPA (1986) has proposed a system for characterizing the overall weight of evidence based on the availability of animal, human, and other supportive data. The weight-of-evidence classification is an attempt to determine the likelihood that an agent is a human carcinogen and thus qualitatively affects the estimation of potential health risks. Three major factors are considered in characterizing the overall weight of evidence for human carcinogenicity:

- The availability and quality of evidence from human studies
- The availability and quality of evidence from animal studies
- Other supportive information that is assessed to determine whether the overall weight of evidence should be modified

Under EPA's risk assessment guidelines (EPA 1986, 1996, 1999), classification of the overall weight of evidence has the following five categories:

- Group A - Human Carcinogen: There is at least sufficient evidence from human epidemiological studies to support a causal association between an agent and cancer.
- Group B - Probable Human Carcinogen: There is at least limited evidence from epidemiological studies of carcinogenicity in humans (Group B1), or, in the absence of adequate data in humans, there is sufficient evidence of carcinogenicity in animals (Group B2).
- Group C - Possible Human Carcinogen: There is inadequate evidence of carcinogenicity in humans.
- Group D - Not Classified: There is inadequate data or no existing data for the chemical.
- Group E - No Evidence of Carcinogenicity in Humans: There is no evidence for carcinogenicity in at least two adequate animal tests in different species, or in both epidemiological and animal studies.

The 2005 (EPA 2005a) Cancer Guidelines provide an update to the Cancer Guidelines (EPA 1986, 1996, 1999). The 2005 Cancer Guidelines emphasize the value of understanding the biological changes that a chemical can cause and how these changes might lead to the development of cancer. They also discuss methods to evaluate and use such information, including information about an agent's postulated mode of action, or the series of steps and processes that lead to cancer formation. Mode-of-action data, when available and of sufficient quality, may be useful to draw conclusions about the potency of an agent, its potential effects at low doses, whether findings in animals are relevant to humans, and which populations or life stages may be particularly susceptible. In the absence of mode-of-action information, default options are available to allow the risk assessment to proceed.

The 2005 Guidelines recommend that an agent's human cancer potential be described in a weight-of-evidence narrative rather than the previously identified letter categories (A = known, B = probable, C = possible, D = not classifiable, and E = non-human carcinogen). The narrative summarizes the full range of available evidence and describes any conditions associated with conclusions about an agent's hazard potential. For example, the narrative may explain that an agent appears to be carcinogenic by some routes of exposure but not others (e.g., by inhalation but not ingestion). Similarly, a hazard may be attributed to exposures during sensitive life stages of development but not at other times. The narrative also summarizes uncertainties and key default options that have been invoked.

The following are the five recommended standard hazard descriptors:

- Carcinogenic to human
- Likely to be carcinogenic to humans
- Suggestive evidence of carcinogenic potential
- Inadequate information to assess carcinogenic potential
- Not likely to be carcinogenic to humans

EPA is evaluating the carcinogenic weight of evidence of chemicals through the IRIS chemical process. In this process, chemicals are nominated, and all chemicals are evaluated consistent with the 2005 Guidelines and a narrative developed describing the Weight of Evidence. The IRIS chemical file is then reviewed, first through

internal EPA consensus review and then external peer-review. The requirements for in-depth analysis of mode-of-action data and the review process does not allow the equating of a chemical evaluated under the old system with the letter classification using the 2005 Classification narrative; rather, a full analysis of the data is required.

The 2005 Cancer Guidelines also include Supplemental Guidance on the evaluation of early lifetime exposures including the mutagenic mode of action for carcinogenesis. The Supplemental Guidance provides procedures for evaluating chemicals that are carcinogens and either using the data in the development of the potency factors or using age dependent adjustment factors. For chemicals with mutagenic mode of action, the following ratio is applied to the chronic daily intake (EPA 2005b):

- Age 0 to less than 2 years: 10
- Age 2 to less than 16 years: 3
- Age greater than or equal to 16 years: 1

The Supplemental Guidance also provides for the evaluation of data on early lifetime exposures where children may be more susceptible. The application of these adjustments for specific chemicals is noted in the risk assessment and, where appropriate, in the presentation of calculated risks.

5.3 Toxicity Values

Tables 5-1 summarize the chronic RfDs and Tables 5-2 through 5-4 summarize chronic, subchronic, and acute RfCs used to estimate noncancer effects. In accordance with the inhalation guidance (EPA 2009), the RfC based on the next longer duration of exposure duration is used as a conservative estimate where the subchronic or acute RfC is not available. For instance, where the subchronic RfC is not available, the chronic RfC is used. Tables 5-5 and 5-6 summarize the cancer SFs and IURs used to estimate cancer risks. These criteria are the most current data, obtained from the November 2011 on-line version of IRIS, PPRTVs provided by EPA Region 2, the July 2009 on-line version of Cal/EPA Office of Environmental Health Hazard Assessment Toxicity Criteria Database, and the December 2009 on-line version of ATSDR. The use of surrogate toxicity values is noted in Tables 5-1 through 5-6.

Seven PAHs have been classified by EPA as Group 2, probable human carcinogens. Toxicity values are currently available only for benzo(a)pyrene. Dibenzo(a,h)anthracene is assessed using the PAH-specific relative potency factor (RPF) that expresses the potency relative to benzo(a)pyrene (EPA 1993). The RPF is applied to derive an oral SF for dibenzo(a,h)anthracene.

Carcinogenic PAHs have been identified as having mutagenic mode of action and may have a greater cancer impact if exposure occurs during childhood (EPA 2005b). Additionally, TCE is considered carcinogenic by a mutagenic mode of action for induction of kidney tumors, which means those exposed to TCE are assumed to have increased early-life (< 16 years of age) susceptibility to kidney tumors (EPA 2011c). Dose estimates for these mutagens are adjusted upward to include both early-life exposures that may result in the occurrence of cancer during childhood and early-life exposures that may contribute to cancers later in life.

Section 6
Risk Characterization

In this section of the risk assessment, the human health risks potentially associated with the complete human exposure pathways identified in Section 4 are assessed. Potential risks due to exposures to COPCs in soil, groundwater, surface water, and sediment from the site are evaluated by integrating toxicity and exposure assessments into quantitative expressions of cancer risk and noncancer health hazards.

The potential for noncancer health effects is evaluated by comparing an exposure level over a specified time period with an RfD or RfC derived for a similar exposure period. This ratio of exposure to toxicity is referred to as an HQ. The HI is the sum of the HQs from individual chemicals and exposure routes. This HI assumes that there is a level of exposure below which it is unlikely even for sensitive populations to experience adverse health effects. If the HI exceeds unity (one), there may be concern for potential noncancer effects. However, this value should not be interpreted as a probability; generally, the greater the HI is above unity, the greater the level of concern.

Cancer risks are estimated as the incremental probability of an individual to develop cancer over a lifetime as a result of exposure to a potential carcinogen. The upper-bound excess lifetime cancer risk is estimated by multiplying the lifetime exposure estimated in the exposure assessment (Section 4) by the SF or IUR identified in the toxicity assessment (Section 5). Excess lifetime cancer risks are generally expressed in scientific notation and are probabilities. An excess lifetime cancer risk of 1×10^{-6} (one in one million), for example, represents the incremental probability that an individual will develop cancer as a result of exposure to a cancer chemical over a 70-year lifetime under specified exposure conditions. Because there are multiple cancer types for TCE but the finding of a mutagenic mode of action applies to kidney only, cancer risks from TCE are calculated to account for increased early-life susceptibility for kidney cancer and contribution from other cancer types (EPA 2011c).

In general, EPA recommends a target HI value of unity and a target cancer risk range of 1×10^{-6} to 1×10^{-4} as threshold values for potential human health impacts. The results presented in the spreadsheet calculations are compared to these target values. These values aid in determining whether additional response action is necessary at the site. Cancer risk and noncancer hazard calculations for all COPCs are presented in RAGS Part D Tables B-7.1 through B-7.10 and summarized in RAGS Part D Tables B-9.1 through B-9.10 and B-10.1 through B-10.10 in Appendix B.

6.1 Results of Risk Calculations

Risks for all receptors are estimated using RME assumptions. Risks are also estimated using CTE assumptions when the RME assumptions resulted in risk estimates above EPA's thresholds. The comparison of RME and CTE risks provides information about the degree to which variability in and uncertainty associated with receptor behavior (e.g., amount of water a child ingests per day) influence the risk estimates. CTE risks represent typical exposure patterns rather than the highest possible exposure that is reasonably expected to occur. Cancer risk and noncancer health hazard estimates for each receptor by exposure area are summarized in Table 6-1.

6.1.1 Current Land-Use Scenario

6.1.1.1 Commercial/Industrial Worker

6.1.1.1.1 Former Sugar Mill

Current commercial/industrial workers may come into contact with contaminants in surface soil and groundwater. Risk calculations are presented in Tables B-7.1, B-9.1, and B-10.1 in Appendix B for the RME

scenario and Tables F-7.1, F-9.1, and F-10.1 in Appendix F for the CTE scenario. The total estimated excess cancer risks for current commercial/industrial workers (4×10^{-5}) are within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario.

Under the RME scenario, total noncancer target organ/effects HIs for current commercial/industrial workers are kidney (5) and respiratory system (4) which are above EPA's threshold of unity. When a more typical exposure is considered under the CTE scenario, the target organ/effect HIs for the kidney (3) and respiratory system (3) are still greater than unity (1). The potential health hazards to the kidney and respiratory system are results of exposure to vanadium in groundwater.

Current commercial/industrial workers may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. A vapor intrusion screening is performed on the groundwater concentration in Table E-1 in Appendix E where five chemicals have maximum concentrations greater than their respective screening criteria. All these chemicals, except bromoform, are selected as COPCs in groundwater. As discussed in Appendix E, vapor intrusion is not a concern because the existing structures are not near the COPC concentrations which exceed the screening levels and no detections of COPCs were above the screening levels at the top of the water table.

6.1.1.1.2 Puerto Rico Beverage

Workers may come into contact with contaminants in surface soil and groundwater. Risk calculations are presented in Tables B-7.5, B-9.5, and B-10.5 in Appendix B for the RME scenario and Tables F-7.3, F-9.3, and F-10.3 in Appendix F for the CTE scenario. The total estimated excess cancer risks for current/future commercial/industrial workers (4×10^{-5}) are within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario.

Total noncancer HIs for current commercial/industrial workers under both RME (5) and CTE (3) scenarios are above EPA's threshold of unity. Under the RME scenario, the target organ/effect HIs for the kidney (4) and respiratory system (4) are greater than 1. Under the CTE scenario, the target organ/effect HIs for the kidney (3) and respiratory system (3) are still greater than 1. The potential health hazards to the kidney and respiratory system are results of exposure to vanadium in groundwater.

Similar to the current commercial/industrial workers in the Former Sugar Mill area, current commercial/industrial workers in the Puerto Rico Beverage area may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. As discussed in Section 6.1.1.1.1, vapor intrusion screening is performed on the groundwater concentration in Table E-1 in Appendix E, which concludes vapor intrusion is not a concern.

6.1.1.2 Trespasser

6.1.1.2.1 Former Sugar Mill

Trespassers may come into contact with contaminants in surface soil while trespassing in the Former Sugar Mill area. Risk calculations are presented in Tables B-7.2, B-9.2, and B-10.2 in Appendix B. Under the RME scenario, the total estimated excess cancer risks (9×10^{-7}) are below EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4}, and total noncancer HI (0.8) is below EPA's threshold of unity.

6.1.1.2.2 Puerto Rico Beverage

Trespassers may come into contact with contaminants in surface soil while trespassing in the Puerto Rico Beverage area. Risk calculations are presented in Tables B-7.6, B-9.6, and B-10.6 in Appendix B. Under the RME scenario, the total estimated excess cancer risks (1×10^{-6}) are at the lower end of EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} and total noncancer HI (0.7) is below EPA's threshold of unity.

6.1.1.3 Resident at Former Sugar Mill

Current residents may come into contact with contaminants in surface soil and groundwater. Risk calculations are presented in Tables B-7.3, B-9.3, and B-10.3 in Appendix B for the RME scenario and Tables F-7.2, F-9.2, and F-10.2 in Appendix F for the CTE scenario. The total estimated excess cancer risks for residents (2×10^{-4}) are above EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario but within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} under the CTE scenario (8×10^{-5}).

Total noncancer HI for current residents under the RME scenario (36) is above EPA's threshold of unity. The target organ/effect HIs for the kidney (32), respiratory system (30), lung (2), and gastrointestinal (GI) tract (2) are greater than 1. The potential health hazards to the kidney are results of exposure to *cis*-1,2-DCE and vanadium in groundwater, while the potential adverse health effects to the respiratory system are results of exposure of vanadium in soil and groundwater. The potential adverse health effects to the lung and GI tract are mainly results of exposure to arsenic and iron, respectively, in both soil and groundwater. Under the CTE scenario, total noncancer HI for residents (16) is still above EPA's threshold of unity. The target organ/effect HIs for the kidney (14) and respiratory system (13) are greater than 1.

Similar to the commercial/industrial workers, current residents may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. As discussed in Section 6.1.1.1.1 vapor intrusion screening is performed on the groundwater concentration in Table E-1 in Appendix E, which concludes vapor intrusion is not a concern.

6.1.1.4 Recreational User at Maunabo River

Current recreational users may come into contact with contaminants in surface water and sediment at the Maunabo River while recreating at the site. Risk calculations are presented in Tables B-7.9, B-9.9, and B-10.9 in Appendix B. The total estimated excess cancer risks for current recreational users (9×10^{-7}) are below EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario. Total noncancer HI for recreational users (1) is at EPA's threshold of unity.

6.1.2 Future Land-Use Scenario

6.1.2.1 Commercial/Industrial Worker

6.1.2.1.1 Former Sugar Mill

Similar to current commercial/industrial workers, the future workers may come into contact with contaminants in surface soil and groundwater. Future commercial/industrial workers may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. A vapor intrusion screening is performed on the groundwater concentration in Table E-1 in Appendix E, which concludes vapor intrusion is not a concern. Risk calculations are presented in Tables B-7.1, B-9.1, and B-10.1 in Appendix B for the RME scenario and Tables F-7.1, F-9.1, and F-10.1 in Appendix F for the CTE scenario. The total estimated excess cancer risks for current/future commercial/industrial workers (4×10^{-5}) are within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario.

Total noncancer HIs for future commercial/industrial workers for both the RME (5) and CTE (4) scenarios are above EPA's threshold of unity. The target organ/effect HIs for the kidney (5) and respiratory system (4) are greater than 1. When a more typical exposure is considered under the CTE scenario, the target organ/effect HIs for the kidney (3) and respiratory system (3) are still greater than one. The potential health hazards to the kidney and respiratory system are results of exposure of vanadium in groundwater.

6.1.2.1.2 Puerto Rico Beverage

Future commercial/industrial workers may come into contact with contaminants in surface soil and groundwater. Workers may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. A vapor intrusion screening is performed on the groundwater concentration in Table E-1 in Appendix E, which concludes vapor intrusion is not a concern. Risk calculations are presented in Tables B-7.5, B-9.5, and B-10.5 in Appendix B for the RME scenario and Tables F-7.3, F-9.3, and F-10.3 in Appendix F for CTE scenario. The total estimated excess cancer risks for commercial/industrial workers (4×10^{-5}) are within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario.

Total noncancer HIs for commercial/industrial workers for both the RME (5) and CTE (3) scenarios are above EPA's threshold of unity. The target organ/effect HIs for the kidney (4) and respiratory system (4) are greater than 1. When a more typical exposure is considered under the CTE scenario, the target organ/effect HIs for the kidney (3) and respiratory system (3) are still greater than 1. The potential health hazards to the kidney and respiratory system are results of exposure of vanadium in groundwater.

6.1.2.2 Trespasser

6.1.2.2.1 Former Sugar Mill

Future trespassers may come into contact with contaminants in surface soil while trespassing in the Former Sugar Mill Area. Risk calculations for the RME are presented in Tables B-7.2, B-9.2, and B-10.2 in Appendix B. Under the RME scenario, the total estimated excess cancer risks for future trespassers (9×10^{-7}) are below EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4}, and total noncancer HI for future trespassers (0.8) is below EPA's threshold of unity.

6.1.2.2.2 Puerto Rico Beverage

Future trespassers may come into contact with contaminants in surface soil while trespassing in the Puerto Rico Beverage area. Risk calculations are presented in Tables B-7.6, B-9.6, and B-10.6 in Appendix B. Under the RME scenario, the total estimated excess cancer risks for trespassers (1×10^{-6}) are at the lower end of EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4}, and total noncancer HI for trespassers (0.7) is below EPA's threshold of unity.

6.1.2.3 Resident

6.1.2.3.1 Former Sugar Mill

Future residents may come into contact with contaminants in surface soil and groundwater and may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. A vapor intrusion screening is performed on the groundwater concentration in Table E-1 in Appendix E, which concludes vapor intrusion is not a concern. Risk calculations are presented in Tables B-7.3, B-9.3, and B-10.3 in Appendix B for the RME scenario and Tables F-7.2, F-9.2, and F-10.2 in Appendix F for the CTE scenario. The total estimated excess cancer risks for current/future residents (2×10^{-4}) are slightly above EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario but within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} under the CTE scenario (8×10^{-5}).

Total noncancer HI for current/future residents for under the RME scenario (36) is above EPA's threshold of unity. The target organ/effect HIs for the kidney (32), respiratory system (30), lung (2), and GI tract (2) are greater than 1. The potential health hazards to the kidney are results of exposure to *cis*-1,2-DCE and vanadium in groundwater, while the potential adverse health effects to the respiratory system are results of exposure to vanadium in soil and groundwater. The potential adverse health effects to the lung and GI tract are mainly results of exposure to arsenic and iron, respectively, in both soil and groundwater. Under the CTE scenario, total

noncancer HI for current/future residents (16) is still above EPA's threshold of unity. The target organ/effect HIs for the kidney (14) and respiratory system (13) are still greater than 1.

6.1.2.3.2 Puerto Rico Beverage

Future residents may come into contact with contaminants in surface soil and groundwater and may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. A vapor intrusion screening is performed on the groundwater concentration in Table E-1 in Appendix E, which concludes vapor intrusion is not a concern. Risk calculations are presented in Tables B-7.7, B-9.7, and B-10.7 in Appendix B for the RME scenario and Tables F-7.4, F-9.4, and F-10.4 in Appendix F for the CTE scenario. The total estimated excess cancer risks for current/future residents (2×10^{-4}) are slightly above EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario but within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} under the CTE scenario (8×10^{-5}).

Total noncancer HI for current/future residents under the RME scenario (34) is above EPA's threshold of unity. The target organ/effect HIs for the kidney (31), respiratory system (29), and lung (2) are greater than 1. The potential health hazards to the kidney are results of exposure to *cis*-1,2-DCE and vanadium in groundwater, while the potential adverse health effects to the respiratory system are results of exposure of vanadium in soil and groundwater. The potential adverse health effects to the lung are mainly results of exposure to arsenic in both soil and groundwater. When a more typical exposure is considered, under the CTE scenario, total noncancer HI for current/future residents (15) is still above EPA's threshold of unity. The target organ/effect HIs for the kidney (13) and respiratory system (13) are still greater than 1.

6.1.2.3.3 Maunabo River

Future residents may come into contact with contaminants in surface water from the Maunabo River as potable water uses. Risk calculations are presented in Tables B-7.10, B-9.10, and B-10.10 in Appendix B. Under the RME scenario, the total estimated excess cancer risks for future residents (2×10^{-5}) are within EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4}, and total noncancer HI for future residents (0.007) is below EPA's threshold of unity.

6.1.2.4 Future Construction Worker

6.1.2.4.1 Former Sugar Mill

Future construction workers may come into contact with contaminants in surface and subsurface soil while working at the site. Risk calculations are presented in Tables B-7.4, B-9.4, and B-10.4 in Appendix B. The total estimated excess cancer risks for future construction workers (2×10^{-7}) are below EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario. Total noncancer HI for future construction workers (2) is above EPA's threshold of unity. The target organ/effect HIs for the kidney (2) and respiratory system (2) are greater than 1. The potential health hazards to the kidney and respiratory system are results of exposure to vanadium in soil.

6.1.2.4.2 Puerto Rico Beverage

Future construction workers may come into contact with contaminants in surface and subsurface soil while working at the site. Risk calculations are presented in Tables B-7.8, B-9.8, and B-10.8 in Appendix B. The total estimated excess cancer risks for future construction workers (8×10^{-8}) are below EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario. Total noncancer HI for future construction workers (2) is above EPA's threshold of unity. The target organ/effect HIs for the kidney (2) and respiratory system (2) are greater than 1. The potential health hazards to the kidney and respiratory system are results of exposure of vanadium in soil.

6.1.2.5 Future Recreational User at Maunabo River

Future recreational users may come into contact with contaminants in surface water and sediment at the Maunabo River while recreating at the site. Risk calculations are presented in Tables B-7.9, B-9.9, and B-10.9 in

Appendix B. The total estimated excess cancer risks for future recreational users (9×10^{-7}) are below EPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} for the RME scenario. Total noncancer HI for recreational users (1) is at EPA's threshold of unity.

6.2 Risk Associated with Exposure to Lead

As shown in Table 3-1, for residential exposure scenario, mean concentrations of lead in groundwater and in surface soil at the Former Sugar Mill and Puerto Rico Beverage areas are below EPA Regional Screening Level of 400 mg/kg in soil and 15 µg/L, Puerto Rico Water Quality Standard for Class SG Groundwater.

For non-residential exposure scenario, similar to the residential exposure scenario, surface soil, subsurface soil collected at both Former Sugar Mill and Puerto Rico Beverage areas have lead concentrations below EPA Regional Screening Levels for surface soil of 400 mg/kg and 800 mg/kg for surface/subsurface soil. Lead concentration in groundwater is also below Puerto Rico Water Quality Standard for Class SG Groundwater (15 µg/L). In addition, lead concentration in sediment at Maunabo River is also below EPA Regional Screening Level of 400 mg/kg.

6.3 Uncertainty in Risk Assessment

As in any risk assessment, the estimates of potential health threats (cancer risks and noncancer health hazards) have numerous associated uncertainties. The primary areas of uncertainty and limitations are qualitatively discussed here. The main areas of uncertainty in this HHRA include environmental data, exposure parameter assumptions, toxicological data, and risk characterization.

6.3.1 Environmental Data

Uncertainty is often associated with the estimation of chemical concentrations. Errors in the analytical data may stem from errors inherent in sampling and/or laboratory procedures. One of the most effective methods to minimize procedural or systematic error is to subject the data to a strict QC review. The QC review procedure helps to eliminate many laboratory errors. However, even with all data rigorously validated, it must be realized that error is inherent in all laboratory procedures.

Samples were collected from known and suspected areas of contamination (biased sampling) to delineate the nature and extent of contamination. Although this sampling methodology provided a reasonable estimation of the level of confidence at known or suspected contaminated areas within the site, the possibility exists that the data sets formed by these samples do not accurately represent the level of overall contamination at the site. The large number of soil, groundwater, surface water, and sediment samples taken from the site, reduces uncertainty to an acceptable level in most cases.

The groundwater data that were used in this assessment contribute a significant degree of uncertainty to the overall assessment. Among the factors that should be considered is our ability to estimate risk in the future. The presumption that contaminant concentrations will remain the same over time may overestimate the potential risk because dispersion and other natural processes are not accounted for.

6.2.2 Exposure Parameter Estimation

There are two major areas of uncertainty associated with exposure parameter estimation. The first relates to the calculation of EPCs. The second relates to parameter values used to estimate chemical intake.

6.2.2.1 Exposure Point Concentrations

A baseline risk assessment evaluates mean concentrations over an exposure unit, considering all exposures within that area as equally possible. Risks associated with exposures are then assessed by evaluating those

average or mean concentrations with exposure factors and the appropriate exposure/toxicity values. In accordance with ProUCL recommendation (EPA 2010b), when 5 or more samples are collected with at least 4 samples are detected, the EPC for a specific chemical in a particular medium is based on the 95 percent or higher UCL on the mean or the maximum detected concentration, whichever is less. Use of a 95 percent or higher UCL of the mean is simply to ensure that the average concentration is not underestimated.

When calculating EPCs from sampling data, any approach dealing with non-detected chemical concentrations is associated with some degree of uncertainty. This is because the non-detected result does not indicate whether the chemical is absent from the medium, present at a concentration just above zero, or present at a concentration just below the reporting limit. For chemicals that are infrequently detected, many of the values used to estimate the EPCs are based on reporting limits. High reporting limits for non-detects can lead to overestimation of risk if the actual concentrations are well below the reporting limit. However, reporting limits for the COPCs were generally toward the lower end of the detected concentrations, so the 95 percent or higher UCLs on the mean were minimally influenced by the reporting limits.

6.2.2.2 Exposure Parameters

Uncertainty is associated with the exposure parameter values used; however, assumptions are chosen to be conservative so as not to underestimate risk. For example, assumptions are made for the exposure time, frequency, and duration of potential chemical exposures, as well as for the quantity of material ingested, inhaled, or absorbed. In general, assumptions are made based on reasonable maximum exposures and, in most cases, values are specified by EPA Region 2, EPA guidance documents, or site-specific information.

The choices made for exposure parameters are protective and are unlikely to underestimate risks. Cancer risks and health hazards could be overestimated based on use of conservative exposure parameters in estimating risks. Certainly, the goal of estimating risks well above the average and at the upper end of possible risks was likely achieved. Such estimates typically form the basis for risk management.

Vapor concentrations in bathrooms were modeled using the shower model. The model is very conservative; thus, this approach tends to produce conservative indoor air concentrations that could result in overestimation of actual risk to current and future residents and commercial/industrial workers.

In the case of the dermal absorption factor, chemical-specific values based on EPA guidance are not available for the VOCs and most metals. Therefore, dermal risk associated with these chemicals cannot be quantitatively evaluated for the risk assessment, which introduces some uncertainty in total risk and total hazard estimates. However, for most chemicals, ingestion is expected to be the primary exposure pathway of concern.

6.2.3 Toxicological Data

A potentially large source of uncertainty is inherent in the derivation of the EPA toxicity values (i.e., RfDs, RfCs, SFs, and IURs). In many cases, data are extrapolated from animals to sensitive humans by the application of uncertainty factors to an estimated NOAEL or lowest-observed-adverse-effect level for noncancer health effects. While designed to be protective, it is likely in many cases that uncertainty factors overestimate the magnitude of differences that may exist between humans and animals, and among humans.

In some cases, however, toxicity values may be based on studies that did not detect the most sensitive adverse effects. For example, many past studies have not measured possible toxic effects on the immune system. Moreover, some chemicals may cause subtle effects not easily recognized in animal studies.

In addition, derivation of cancer SFs often involves linear extrapolation of effects at high doses to potential effects at lower doses commonly seen in environmental exposure settings. Currently, it is not known whether

linear extrapolation is appropriate. It is probable that the shape of the dose response curve for carcinogenesis varies with different chemicals and mechanisms of action. It is not possible at this time, however, to describe such differences in quantitative terms.

It is likely that the assumption of linearity is conservative and yields SFs that are unlikely to lead to underestimation of risks. Yet, for specific chemicals, current methodology could cause SFs and, hence, risks to be underestimated.

Use of SFs for arsenic, especially the oral SF based on exposure of a large Taiwanese population to dissolved arsenic in drinking water, is controversial. Some evidence exists that metabolism of arsenic in the body may greatly reduce possible cancer risks at lower levels of exposure.

Acute RfCs are not available for some metals. In accordance with RAGS Part F (EPA 2009), the RfC based on the next longer exposure duration is used as a conservative estimate that would be protective for the shorter exposure duration. This source of uncertainty may overestimate the potential inhalation hazard for trespassers and recreational users.

6.2.4 Risk Characterization

There is also uncertainty in assessing the risks associated with a mixture of chemicals. In this assessment, the effects of exposure to each contaminant present have initially been considered separately. However, these substances occur together at the site, and individuals may be exposed to mixtures of the chemicals. Predictions of how these mixtures of chemicals will interact must be based on an understanding of the mechanisms of such interactions. Individual chemicals may interact chemically in the body, yielding a new toxic component or causing different effects at different target organs. Suitable data are not currently available to rigorously characterize the effects of chemical mixtures. Consequently, as recommended by EPA (1989), chemicals present at the site are assumed to act additively, and potential health risks are evaluated by summing excess lifetime cancer risks and calculating HIs for noncancer health effects.

This approach to assessing risk associated with mixtures of chemicals assumes that there are no synergistic or antagonistic interactions among the chemicals and that all chemicals have the same toxic endpoint and mechanisms of action. To the extent that these assumptions are correct, the actual risks could be underestimated or overestimated.

As a result of the uncertainties described above, this risk assessment should not be construed as presenting absolute risks or hazards. Rather, it is a conservative analysis intended to indicate the potential for adverse impacts to occur based on the RME and the CTE scenarios.

The bedrock in the Maunabo area is composed of the San Lorenzo Batholith, granitic rock that includes a variety of igneous rock types, including granodiorite, diorite, gabbro, and tonalite. These igneous rock types are generally composed of minerals with significant percentage of iron and manganese. The batholith weathers to form the alluvial material within the Maunabo river valley. Therefore, the elevated detections of some metals in groundwater result from the natural alluvial material that has weathered from the igneous bedrock and are not indicative of metal sources of contamination.

Section 7
Summary of Risk Assessment

7.1 Approach

COPCs are identified based on criteria outlined in RAGS (EPA 1989), primarily through comparison to risk-based screening levels. COPCs identified for further quantitative evaluation in the HHRA are primarily VOCs, SVOCs, and inorganics as listed in Table 3-2.

In the HHRA, contaminants in various media at the site are evaluated for potential health threats to the following receptors:

- Current Land-Use Scenario
  - Commercial Industrial Workers
    - Former Sugar Mill
    - Puerto Rico Beverage
  - Trespassers
    - Former Sugar Mill
    - Puerto Rico Beverage
  - Residents
    - Former Sugar Mill
  - Recreational Users
    - Maunabo River
- Future Land-Use Scenario
  - Commercial Industrial Workers
    - Former Sugar Mill
    - Puerto Rico Beverage
  - Trespassers
    - Former Sugar Mill
    - Puerto Rico Beverage
  - Residents
    - Former Sugar Mill
    - Puerto Rico Beverage
    - Maunabo River
  - Recreational Users
    - Maunabo River
  - Construction Workers
    - Former Sugar Mill
    - Puerto Rico Beverage

Exposure routes and human receptor groups are identified and quantitative estimates of the magnitude, frequency, and duration of exposure are made. Exposure point concentrations are estimated using the lower of the UCL and the maximum detected concentration. Daily intakes are calculated based on the RME scenario (the highest exposure reasonably expected to occur at a site). The intent is to estimate a conservative exposure case that is still within the range of possible exposures. CTE assumptions are also developed, which reflect more typical exposures.

In the toxicity assessment, current toxicological human health data (i.e., RfDs, RfCs, SFs, and IURs) are obtained from various sources and are utilized in the order specified by EPA (2003).

Risk characterization involves integrating the exposure and toxicity assessments into quantitative expressions of risks/health effects. Specifically, daily intakes are compared with concentrations known or suspected to present health risks or hazards. The estimates of cancer risk and noncancer health hazards, and the greatest chemical contributors to these estimates, are identified.

In general, EPA recommends target values or ranges (i.e., cancer risk of 10^{-6} to 10^{-4} or HI of 1) as threshold values for potential human health impacts (EPA 1989). These target values aid in determining whether additional response action is necessary at the site.

7.2 Site Risks

This section presents a summary of the cancer risks and noncancer health hazards for exposures to contaminants in various media at the site that are quantitatively evaluated for potential health threats.

7.2.1 Current Land-Use Scenario

7.2.1.1 Cancer Risk

The total incremental lifetime cancer risk estimates for the RME scenario, except risks are above EPA's target range of 1×10^{-6} to 1×10^{-4}, for current land-use receptors are listed below.

- Commercial Industrial Workers
  - Former Sugar Mill: 4×10^{-5}
  - Puerto Rico Beverage: 4×10^{-5}
- Trespassers
  - Former Sugar Mill: 9×10^{-7}
  - Puerto Rico Beverage: 1×10^{-6}
- Residents
  - Former Sugar Mill: RME: 2×10^{-4}; CTE: 8×10^{-5}
- Recreational Users
  - Maunabo River: 9×10^{-7}

Based on the results above, the estimated cancer risks for all current receptors are either below or within EPA's target range of 1×10^{-6} to 1×10^{-4} for the RME scenario, except residents at the Former Sugar Mill area. The estimated cancer risk for residents (2×10^{-4}) exceeds EPA's target range of 1×10^{-6} to 1×10^{-4}. When a more typical exposure is considered under the CTE scenario, cancer risks for residents (8×10^{-5}) are within EPA's target range of 1×10^{-6} to 1×10^{-4}.

7.2.1.2 Noncancer Health Hazard

HIs greater than 1 indicate the potential for noncancer health hazards. The estimated organ/effect HIs for the RME scenario, except HIs are above EPA's threshold of unity, are listed below.

- Commercial Industrial Workers
  - Former Sugar Mill:
    - RME: Total HI: 5, HI Kidney: 5, HI Respiratory System: 4
    - CTE: Total HI: 4, HI Kidney: 3, HI Respiratory System: 3

  - Puerto Rico Beverage:
    - RME: Total HI: 5, HI Kidney: 4, HI Respiratory System: 4
    - CTE: Total HI: 3, HI Kidney: 3, HI Respiratory System: 3

- Trespassers
  - Former Sugar Mill: 0.8
  - Puerto Rico Beverage: 0.7

- Residents
  - Former Sugar Mill:
    - RME: Total HI: 36, HI Kidney: 32, HI Respiratory System: 30, HI Lung: 2, HI GI Tract: 2
    - CTE: Total HI: 16, HI Kidney: 14, HI Respiratory System: 13

- Recreational Users
  - Maunabo River: 1

Based on the results above, the total HIs for all current receptors, except commercial/industrial workers and residents at the Former Sugar Mill area, are either below or at EPA's threshold of unity (1). Current commercial/industrial workers have noncancer HIs for kidney and respiratory system exceeding EPA's threshold of 1 under both RME and CTE scenarios. The potential health hazards are mostly attributed to vanadium. The current residents have noncancer HIs for the kidney, respiratory system, lung, and GI tract exceeding EPA threshold of 1 under the RME scenario. The potential health hazards to the kidney are results of exposure to *cis*-1,2-DCE and vanadium in groundwater, while the potential adverse health effects to the respiratory system are results of exposure to vanadium in soil and groundwater. The potential adverse health effects to the lung and GI tract are mainly results of exposure of arsenic and iron, respectively, in both soil and groundwater. Under the CTE scenario, total noncancer HIs for the kidney and respiratory system still exceed EPA's threshold of unity.

7.2.2 Future Land-Use Scenario

Risk characterization results for all future receptors remain the same as those for the current receptors, except for the receptors summarized below.

7.2.2.1 Cancer Risk

The total incremental lifetime cancer risk estimates are listed below.

- Residents
  - Puerto Rico Beverage: RME: 2×10^{-4}; CTE: 8×10^{-5}
  - Maunabo River: 2×10^{-5}

- Future Construction Workers
  - Former Sugar Mill: 2×10^{-7}
  - Puerto Rico Beverage: 8×10^{-8}

Based on the results above and results presented in Section 7.2.1.1, the estimated cancer risks for all future receptors are either below or within EPA's target range of 1×10^{-6} to 1×10^{-4} for the RME scenario except residents at both the Former Sugar Mill area and the Puerto Rico Beverage area. The estimated cancer risk for these residents (2×10^{-4}) exceeds EPA's target range of 1×10^{-6} to 1×10^{-4}. When a more typical exposure is considered under the CTE scenario, cancer risks for residents are (8×10^{-5}) within EPA's target range of 1×10^{-6} to 1×10^{-4}.

7.2.2.2 Noncancer Health Hazard

The estimated HIs are listed below.

- Residents
  - Puerto Rico Beverage:
    - RME: Total HI: 34, HI Kidney: 31, HI Respiratory System: 29, HI Lung: 2, HI GI Tract: 2
    - CTE: Total HI: 15, HI Kidney: 13, HI Respiratory System: 13
  - Maunabo River: 0.007

- Construction Workers
  - Former Sugar Mill: Total HI: 2, HI Kidney:2, HI Respiratory System: 2
  - Puerto Rico Beverage: Total HI: 2, HI Kidney:2, HI Respiratory System: 2

Based on the results above and results presented in Section 7.2.1.2, the total HIs for all future receptors, except commercial/industrial workers, construction workers, and residents at the Former Sugar Mill area and the Puerto Rico Beverage area, are either below or at EPA's threshold of unity. Future commercial/industrial workers have noncancer HIs for kidney and respiratory system exceeding EPA's threshold of unity under the RME scenario. The potential health hazards are mostly attributed to vanadium. When a more typical exposure is considered under the CTE scenario, the total HI is still above EPA's threshold of unity. Future construction workers have noncancer HIs for kidney and respiratory system exceeding EPA's threshold of unity under the RME scenario. The potential health hazards are mostly attributed to vanadium.

The future residents have noncancer HIs for the kidney, respiratory system, lung, and GI tract exceeding EPA's threshold of unity under the RME scenario. The potential health hazards to the kidney are results of exposure to *cis*-1,2-DCE and vanadium in groundwater, while the potential adverse health effects to the respiratory system are results of exposure to vanadium in soil and groundwater. The potential adverse health effects to the lung and GI tract are mainly results of exposure to arsenic and iron, respectively, in both soil and groundwater. Under the CTE scenario, total noncancer HI for the kidney and respiratory system still exceeds EPA's threshold of unity.

7.3 Summary and Conclusions

For the current and future land-use scenarios, total estimated cancer risks are within EPA's target range (cancer risk of 1×10^{-6} to 1×10^{-4}) for all receptors under the RME scenario, except residents at both the Former Sugar Mill and Puerto Rico Beverage areas. However, under the CTE scenario, the total cancer risks are within EPA's target range of 1×10^{-6} to 1×10^{-4}.

For the current and future land-use scenarios, total noncancer health hazards are within EPA's target threshold (HI of 1) for all receptors under the RME scenario, except commercial and industrial workers, construction workers, and residents at both the Former Sugar Mill and Puerto Rico Beverage areas. The current and future commercial/industrial workers, construction workers, and residents have noncancer HIs exceeding EPA's threshold of unity under the RME scenario for the kidney, respiratory system, lung, and GI tract. Noncancer health hazards for current and future commercial/industrial workers and construction workers are almost entirely due to the hypothetical use of contaminated groundwater as a potable water supply.

For current and future residents, the potential health hazards to the kidney are results of exposure of *cis*-1,2-DCE and vanadium in groundwater, while the potential adverse health effects to the respiratory system are results of exposure to vanadium in soil and groundwater. The potential adverse health effects to the lung and GI tract are mainly results of exposure to arsenic and iron, respectively, in both soil and groundwater. Under the CTE scenario, the HIs still exceed EPA's threshold of unity for the same target organs/effects, except lung and GI tract, affected under the RME.

Current and future commercial/industrial workers and residents may potentially be exposed to volatile COPCs via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion and into ambient air via vaporization. However, vapor intrusion is currently not a concern because the existing structures are not near the COPC concentrations which exceed the screening levels and no detections of COPCs were above the screening levels at the top of the water table.

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Section 8
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Tables

TABLE 3-1
LEAD WORKSHEET
Site Name: Maunabo Groundwater Contamination Site, Maunabo, Puerto Rico
Receptor: Resident (Adult and Child [0-6 years])

A. EXPOSURE SCENARIO: RESIDENTIAL

1. Lead Screening Questions

Medium	Mean Concentration		Screening Level		Basis for Screening Level Value
	Value	Unit	Value	Unit	
Surface Soil (Former Sugar Mill)	177	mg/kg	400	mg/kg	EPA Regional Screening Level for residential soil
Surface Soil (Puerto Rico Beverage)	33.3	mg/kg	400	mg/kg	EPA Regional Screening Level for residential soil
Groundwater	0.294	µg/L	15	µg/L	Puerto Rico Water Quality Standards for Class SG Groundwater

Note: If the Adult Lead Model is used, designate the baseline blood lead level and geometric standard deviation used to calculate the screening level.

2. Lead Model Questions

Question	Response for Non-Residential Lead Model
Was a lead model used? (If "no" explain rationale)	No. The mean lead concentrations are below the screening levels. Therefore, further analysis using a lead model is not warranted.
Which lead model and what version/date was used?	NA
Where are the input values located in the risk assessment report?	NA
Where are the output values located in the risk assessment report?	NA
Was the model run using default values only?	NA
If non-default values were used, where are the rationale for those values located in the risk assessment report?	NA

3. Final Result

Medium	Result	Comment
NA	NA	NA

TABLE 3-1
LEAD WORKSHEET
Site Name: Maunabo Groundwater Contamination Site, Maunabo, Puerto Rico
Receptor: Site Worker (Adult), Commercial/Industrial Worker (Adult), Construction Worker (Adult), Recreational User (Adolescent [7-12 years]), Trespasser (Adolescent [7-12 years])

B. EXPOSURE SCENARIO: NON-RESIDENTIAL

1. Lead Screening Questions

Medium	Mean Concentration		Screening Level		Basis for Screening Level Value
	Value	Unit	Value	Unit	
Surface Soil (Former Sugar Mill)	177	mg/kg	400	mg/kg	EPA Regional Screening Level for residential soil
Surface Soil (Puerto Rico Beverage)	33.3	mg/kg	400	mg/kg	EPA Regional Screening Level for residential soil
Surface/Subsurface Soil (Former Sugar Mill)	81.14	mg/kg	800	mg/kg	EPA Regional Screening Level for industrial soil
Surface/Subsurface Soil (Puerto Rico Beverage)	6.147	mg/kg	800	mg/kg	EPA Regional Screening Level for industrial soil
Groundwater	0.294	µg/L	15	µg/L	Puerto Rico Water Quality Standards for Class SG Groundwater
Sediment (Maunabo River)	0.994	mg/kg	400	mg/kg	EPA Regional Screening Level for residential soil

Note: If the Adult Lead Model is used, designate the baseline blood lead level and geometric standard deviation used to calculate the screening level.

TABLE 3-1
LEAD WORKSHEET
Site Name: Maunabo Groundwater Contamination Site, Maunabo, Puerto Rico
Receptor: Site Worker (Adult), Commercial/Industrial Worker (Adult), Construction Worker (Adult), Recreational User (Adolescent [7-12 years]), Trespasser (Adolescent [7-12 years])

2. Lead Model Questions

Question	Response for Non-Residential Lead Model
Was a lead model used? (If "no" explain rationale)	No. The mean lead concentrations are below respective screening levels. Therefore, further analysis using a lead model is not warranted.
Which lead model and what version/date was used?	NA
Where are the input values located in the risk assessment report?	NA
Where are the output values located in the risk assessment report?	NA
Was the model run using default values only?	NA
If non-default values were used, where are the rationale for those values located in the risk assessment report?	NA

3. Final Result

Medium	Result	Comment
NA	NA	NA

TABLE 3-2
LIST OF CHEMICALS OF POTENTIAL CONCERN
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemicals	Former Sugar Mill		Puerto Rico Beverage		The Site	Maunabo River	
	Surface Soil	Surface/ Subsurface Soil	Surface Soil	Surface/ Subsurface Soil	Groundwater	Surface Water	Sediment
Volatile Organic Compounds							
Bromodichloromethane	--	--	--	--	--	**Yes**	--
cis-1,2-Dichloroethene	--	--	--	--	**Yes**	--	--
Dibromochloromethane	--	--	--	--	No	**Yes**	--
Tetrachloroethene	--	--	--	--	**Yes**	--	--
trans-1,2-Dichloroethene	--	--	--	--	**Yes**	--	--
Trichloroethene	--	--	--	--	**Yes**	--	--
Vinyl Chloride	--	--	--	--	**Yes**	--	--
Semi-volatile Organic Compounds							
Benzo(a)pyrene	**Yes**	**Yes**	No	No	--	--	--
Dibenzo(a,h)anthracene	**Yes**	**Yes**	--	--	--	--	--
Inorganics							
Aluminum	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	No
Arsenic	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	--	**Yes**
Barium	No	No	No	No	**Yes**	No	No
Chromium	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	--	**Yes**
Cobalt	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	--	**Yes**
Copper	No	No	No	No	**Yes**	No	No
Iron	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	--	**Yes**
Manganese	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**
Thallium	No	**Yes**	No	No	No	--	--
Vanadium	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	--	**Yes**

Yes = Selected as COPC
No = Not Selected as COPC
-- = Not Detected
The site = Maunabo Groundwater Contamination Site

TABLE 4-1
SELECTION OF EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor (Age)	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Soil	Surface Soil	Former Sugar Mill	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while at their residence.
						Ingestion	Quant	
						Inhalation	Quant	
			Puerto Rico Beverage	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
	Groundwater	Groundwater	Groundwater	Commercial/ Industrial Worker	Adult	Dermal	Quant	Groundwater is used as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents use groundwater as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
		Indoor Air	Indoor Air	Commercial/ Industrial Worker	Adult	Inhalation	Qual	Workers and residents may be exposed to contaminants in indoor air via vapor intrusion pathway from groundwater. Groundwater concentration is screened against the groundwater for indoor air screening level in the risk assessment.
				Resident	Adult and Child (0-6 yrs)	Inhalation	Qual	

TABLE 4-1
SELECTION OF EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor (Age)	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Surface Water	Surface Water	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in surface water through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
	Sediment	Sediment	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in sediment through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
Future	Soil	Surface Soil	Former Sugar Mill	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while at their residence.
						Ingestion	Quant	
						Inhalation	Quant	
			Puerto Rico Beverage	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while at their residence.
						Ingestion	Quant	
						Inhalation	Quant	

TABLE 4-1
SELECTION OF EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor (Age)	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Soil	Surface and Subsurface Soil	Former Sugar Mill	Construction Worker	Adult	Dermal	Quant	Construction workers may come into contact with contaminants in soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
			Puerto Rico Beverage	Construction Worker	Adult	Dermal	Quant	Construction workers may come into contact with contaminants in soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
	Groundwater	Groundwater	Groundwater	Commercial/ Industrial Worker	Adult	Dermal	Quant	Groundwater is used as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents use groundwater as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
		Indoor Air	Indoor Air	Commercial/ Industrial Worker	Adult	Inhalation	Qual	Workers and residents may be exposed to contaminants in indoor air via vapor intrusion pathway from groundwater. Groundwater concentration is screened against the groundwater for indoor air screening level in the risk assessment.
				Resident	Adult and Child (0-6 yrs)	Inhalation	Qual	
	Surface Water	Surface Water	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in surface water through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may use surface water as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
	Sediment	Sediment	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in sediment through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	

Quant = Quantitative risk analysis performed
Qual = Qualitative risk analysis performed

TABLE 5-1

NONCANCER TOXICITY DATA - ORAL/DERMAL

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal [1]	Absorbed RfD for Dermal [2]		Primary Target Organ	Combined Uncertainty/ Modifying Factor	Source	Date [3]
		Value	Unit		Value	Unit				
Volatile Organic Compounds										
Bromodichloromethane	Chronic	2.0E-02	mg/kg-day	1	2.0E-02	mg/kg-day	Liver	1,000	IRIS	12/2/2011
cis-1,2-Dichloroethene	Chronic	2.0E-03	mg/kg-day	1	2.0E-03	mg/kg-day	Kidney	3,000	IRIS	12/2/2011
Dibromochloromethane	Chronic	2.0E-02	mg/kg-day	1	2.0E-02	mg/kg-day	Liver	1,000	IRIS	12/2/2011
Tetrachloroethene	Chronic	6.0E-03	mg/kg-day	1	6.0E-03	mg/kg-day	Liver	1,000	IRIS	3/20/2012
trans-1,2-Dichloroethene	Chronic	2.0E-02	mg/kg-day	1	2.0E-02	mg/kg-day	Blood	3,000	IRIS	12/2/2011
Trichloroethene	Chronic	5.0E-04	mg/kg-day	1	5.0E-04	mg/kg-day	Heart/ Immunogical/ Developmental/Kidney	10 to 1,000	IRIS	12/2/2011
Vinyl Chloride	Chronic	3.0E-03	mg/kg-day	1	3.0E-03	mg/kg-day	Liver	30	IRIS	12/2/2011
Semi-volatile Organic Compounds										
Benzo(a)pyrene	Chronic	NA	NA	1	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	Chronic	NA	NA	1	NA	NA	NA	NA	NA	NA
Inorganics										
Aluminum	Chronic	1.0E+00	mg/kg-day	1	1.0E+00	mg/kg-day	Neurological	100	PPRTV	10/23/2006
Arsenic	Chronic	3.0E-04	mg/kg-day	1	3.0E-04	mg/kg-day	Skin	3	IRIS	12/2/2011
Barium	Chronic	2.0E-01	mg/kg-day	0.07	1.4E-02	mg/kg-day	Kidney	300	IRIS	12/2/2011
Chromium[4]	Chronic	3.0E-03	mg/kg-day	0.025	7.5E-05	mg/kg-day	None reported	300	IRIS	12/2/2011
Cobalt	Chronic	3.0E-04	mg/kg-day	1	3.0E-04	mg/kg-day	Thyroid	3,000	PPRTV	8/25/2008
Copper	Chronic	4.0E-02	mg/kg-day	1	4.0E-02	mg/kg-day	GI Tract	NA	HEAST	7/1/1997
Iron	Chronic	7.0E-01	mg/kg-day	1	7.0E-01	mg/kg-day	GI Tract	1.5	PPRTV	9/11/2006
Manganese	Chronic	1.4E-01	mg/kg-day	0.04	5.6E-03	mg/kg-day	CNS	1	IRIS	12/2/2011
Thallium	Chronic	1.0E-05	mg/kg-day	1	1.0E-05	mg/kg-day	Skin/Hair	3,000	PPRTV-S	10/8/2010
Vanadium	Chronic	7.0E-05	mg/kg-day	0.026	1.8E-06	mg/kg-day	Kidney	3,000	PPRTV	9/30/2009

[1] Oral Absorption Efficiency for Dermal from Risk Assessment Guidance for Superfund Part E, Supplemental Guidance for Dermal Risk Assessment

[2] Adjusted RfD for Dermal = Oral RfD x Oral Absorption Efficiency for Dermal.

[3] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/
Date shown for other sources is the publication date.

[4] based on chromium (VI)

Definition:

ATSDR = Agency for Toxic Substances and Disease Registry

CNS = central nervous system

GI = gastrointestinal

HEAST = Health Effect Assessment Summary Tables

IRIS = Integrated Risk Information System

mg/kg-day = milligram per kilogram per day

NA = not available

PPRTV = Provisional Peer Reviewed Toxicity Value

PPRTV-S = Screening Provisional Peer Reviewed Toxicity Value

RfD = reference dose

TABLE 5-2
NONCANCER TOXICITY DATA - INHALATION (CHRONIC)
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical of Potential Concern	Inhalation RfC		Primary Target Organ	Combined Uncertainty/ Modifying Factor	RfC Target Organ	
	Value	Unit			Source [1]	Date [2]
Volatile Organic Compounds						
Bromodichloromethane	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
Tetrachloroethene	4.0E-02	mg/m^3	Liver	1,000	IRIS	3/20/2012
trans-1,2-Dichloroethene	6.0E-02	mg/m^3	Lung/Liver	3,000	PPRTV	3/1/2006
Trichloroethene	2.0E-03	mg/m^3	Heart/Immunological	10 to 100	IRIS	12/2/2011
Vinyl Chloride	1.0E-01	mg/m^3	Liver	30	IRIS	12/2/2011
Semi-volatile Organic Compounds						
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA
Inorganics						
Aluminum	5.0E-03	mg/m^3	Neurological	300	PPRTV	10/23/2006
Arsenic	1.5E-05	mg/m^3	Developmental/Cardiovascular System/CNS/Lung/Skin	30	Cal/EPA	12/18/2008
Barium	5.0E-04	mg/m^3	Fetus	1,000	HEAST	7/1/1997
Chromium[3]	1.0E-04	mg/m^3	Lung	300	IRIS	12/2/2011
Cobalt	6.0E-06	mg/m^3	Respiratory System/Lung	300	PPRTV	8/25/2008
Copper	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA
Manganese	5.0E-05	mg/m^3	CNS	1,000	IRIS	12/2/2011
Thallium	NA	NA	NA	NA	NA	NA
Vanadium	1.0E-04	mg/m^3	Respiratory System	30	ATSDR	5/3/2011

[1] ATSDR chronic inhalation minimal risk level (MRL)
MRL is converted from units in ppmv to mg/m^3 using the following equation:

$$MRL\ (mg/m^3) = (ppmv)(1\ kg/1000\ g)(P/RT)(molecular\ weight)$$

where:
P = ambient air pressure, 1 atmosphere (atm)
R = ideal gas constant, 8.2×10^{-5} atm-m^3/mol-^{0}K
T = absolute temperature, 298.15 Kelvin (^{0}K)

[2] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/
Date shown for other sources is the publication date.

[3] based on chromium (VI) particulates

Definition:
ATSDR = Agency for Toxic Substances and Disease Registry
Cal/EPA = California Environmental Protection Agency
CNS = central nervous system
HEAST = Health Effects Assessment Summary Tables
IRIS = Integrated Risk Information System
mg/m^3 = milligram per cubic meter
NA = not available
ppmv = part per million by volume
PPRTV = Provisional Peer Reviewed Toxicity Value
RfC = reference concentration

TABLE 5-3
NONCANCER TOXICITY DATA - INHALATION (ACUTE)
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical of Potential Concern	Inhalation RfC		Primary Target Organ	Combined Uncertainty/ Modifying Factor	RfC Target Organ	
	Value	Unit			Source [1]	Date [2]
Volatile Organic Compounds						
Bromodichloromethane	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
Tetrachloroethene	2.0E+01	mg/m^3	CNS/Eye/Respiratory System	60	Cal/EPA	12/18/2008
trans-1,2-Dichloroethene	7.9E-01	mg/m^3	Liver	1,000	ATSDR	5/3/2011
Trichloroethene	1.1E+01	mg/m^3	CNS	30	ATSDR	5/3/2011
Vinyl Chloride	1.8E+02	mg/m^3	CNS/Eye/Respiratory System	10	Cal/EPA	12/18/2008
Semi-volatile Organic Compounds						
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA
Inorganics						
Aluminum	NA	NA	NA	NA	NA	NA
Arsenic	2.0E-04	mg/m^3	Developmental/Cardiovascular System/CNS	1,000	Cal/EPA	12/18/2008
Barium	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA
Copper	1.0E-01	mg/m^3	Respiratory System	10	Cal/EPA	12/18/2008
Iron	NA	NA	NA	NA	NA	NA
Manganese	1.7E-04	mg/m^3	CNS	300	Cal/EPA	12/18/2008
Thallium	NA	NA	NA	NA	NA	NA
Vanadium[3]	3.0E-02	mg/m^3	Respiratory System/Eyes	10	Cal/EPA	12/18/2008

[1] ATSDR chronic inhalation minimal risk level (MRL)
MRL is converted from units in ppmv to mg/m^3 using the following equation:

$$MRL\ (mg/m^3) = (ppmv)(1\ kg/1000\ g)(P/RT)(molecular\ weight)$$

where:
P = ambient air pressure, 1 atmosphere (atm)
R = ideal gas constant, 8.2×10^{-5} atm-m^3/mol-^{0}K
T = absolute temperature, 298.15 Kelvin (^{0}K)

[2] Date shown is the publication date.
[3] based on vanadium pentoxide

Definition:
ATSDR = Agency for Toxic Substances and Disease Registry
Cal/EPA = California Environmental Protection Agency
CNS = central nervous system
mg/m^3 = milligram per cubic meter
NA = not available
ppmv = part per million by volume
RfC = reference concentration

TABLE 5-4

CANCER TOXICITY DATA - ORAL/DERMAL

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Chemical of Potential Concern	Oral Slope Factor		Oral Absorption Efficiency for Dermal [1]	Absorbed Slope Factor for Dermal [2]		Mutagen [3]	Weight of Evidence/ Cancer Guideline Description	Source	Date [4]
	Value	Unit		Value	Unit				
Volatile Organic Compounds									
Bromodichloromethane	6.2E-02	$(mg/kg\text{-}day)^{-1}$	1	6.2E-02	$(mg/kg\text{-}day)^{-1}$	--	B2	IRIS	12/2/2011
cis-1,2-Dichloroethene	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Dibromochloromethane	8.4E-02	$(mg/kg\text{-}day)^{-1}$	1	8.4E-02	$(mg/kg\text{-}day)^{-1}$	--	C	IRIS	12/2/2011
Tetrachloroethene	2.1E-03	$(mg/kg\text{-}day)^{-1}$	1	2.1E-03	$(mg/kg\text{-}day)^{-1}$	--	Likely to be carcinogenic to humans	IRIS	3/20/2012
trans-1,2-Dichloroethene	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Trichloroethene	4.6E-02	$(mg/kg\text{-}day)^{-1}$	1	4.6E-02	$(mg/kg\text{-}day)^{-1}$	M	carcinogenic to humans	IRIS	12/2/2011
Vinyl Chloride	7.2E-01	$(mg/kg\text{-}day)^{-1}$	1	7.2E-01	$(mg/kg\text{-}day)^{-1}$	M	A	IRIS	12/2/2011
Semi-volatile Organic Compounds									
Benzo(a)pyrene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1	7.3E+00	$(mg/kg\text{-}day)^{-1}$	M	B2	IRIS	12/2/2011
Dibenzo(a,h)anthracene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1	7.3E+00	$(mg/kg\text{-}day)^{-1}$	M	B2	EPA	7/1/1993
Inorganics									
Aluminum	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/23/2006
Arsenic	1.5E+00	$(mg/kg\text{-}day)^{-1}$	0.025	1.5E+00	$(mg/kg\text{-}day)^{-1}$	--	A	IRIS	12/2/2011
Barium	NA	NA	0.07	NA	NA	--	D	IRIS	12/2/2011
Chromium[5]	5.0E-01	$(mg/kg\text{-}day)^{-1}$	1	5.0E-01	$(mg/kg\text{-}day)^{-1}$	--	likely to be carcinogenic to humans	NJDEP	4/8/2009
Cobalt	NA	NA	1	NA	NA	--	NA	NA	NA
Copper	NA	NA	1	NA	NA	--	D	IRIS	12/2/2011
Iron	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	9/11/2006
Manganese	NA	NA	0.04	NA	NA	--	D	IRIS	12/2/2011
Thallium	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/8/2010
Vanadium	NA	NA	0.026	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	9/30/2009

[1] Oral Absorption Efficiency for Dermal from Risk Assessment Guidance for Superfund Part E, Supplemental Guidance for Dermal Risk Assessment

[2] Oral cancer slope factor (CSF) for Dermal = Oral CSF

[3] Identified as a mutagen on the Regional Screening Level (RSL) Table, June 2011 http://www.epa.gov/region09/waste/sfund/prg/index.html

[4] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/ Date shown for other sources is the publication date.

[5] based on chromium (VI)

Definition:

Cal/EPA = California Environmental Protection Agency

EPA = EPA Provisional Guidance for Quantitative Assessment of Polycyclic Aromatic Hydrocarbons

IRIS = Integrated Risk Information System

M = mutagen

mg/kg-day = milligram per kilogram per day

NA = not available

NJDEP = New Jersey Department of Environmental Protection

PPRTV = Provisional Peer Reviewed Toxicity Value

EPA Weight of Evidence (EPA 1986, EPA 1996):

A - Human Carcinogen

B1 - Probable human carcinogen indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as human carcinogen

EPA Weight of Evidence Narrative (EPA 2005):

Carcinogenic to human

Likely to be carcinogenic to humans

Suggestive evidence of carcinogenic potential

Inadequate information to assess carcinogenic potential

Not likely to be carcinogenic to humans

TABLE 5-5
CANCER TOXICITY DATA - INHALATION
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical of Potential Concern	Inhalation Unit Risk		Mutagen [1]	Weight of Evidence/ Cancer Guideline Description	Inhalation Unit Risk	
	Value	Unit			Source	Date [2]
Volatile Organic Compounds						
Bromodichloromethane	3.7E-05	$(\mu g/m^3)^{-1}$	--	B2	Cal/EPA	7/21/2009
cis-1,2-Dichloroethene	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Dibromochloromethane	2.7E-05	$(\mu g/m^3)^{-1}$	--	C	Cal/EPA	7/21/2009
Tetrachloroethene	2.6E-07	$(\mu g/m^3)^{-1}$	--	Likely to be carcinogenic to humans	IRIS	3/20/2012
trans-1,2-Dichloroethene	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Trichloroethene	4.1E-06	$(\mu g/m^3)^{-1}$	M	carcinogenic to humans	IRIS	12/2/2011
Vinyl Chloride	4.4E-06	$(\mu g/m^3)^{-1}$	M	A	IRIS	12/2/2011
Semi-volatile Organic Compounds						
Benzo(a)pyrene	1.1E-03	$(\mu g/m^3)^{-1}$	M	B2	Cal/EPA	7/21/2009
Dibenzo(a,h)anthracene	1.2E-03	$(\mu g/m^3)^{-1}$	M	B2	Cal/EPA	7/21/2009
Inorganics						
Aluminum	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/23/2006
Arsenic	4.3E-03	$(\mu g/m^3)^{-1}$	--	A	IRIS	12/2/2011
Barium	NA	NA	--	D	IRIS	12/2/2011
Chromium[3]	1.2E-02	$(\mu g/m^3)^{-1}$	--	A	IRIS	12/2/2011
Cobalt	9.0E-03	$(\mu g/m^3)^{-1}$	--	likely to be carcinogenic to humans	PPRTV	8/25/2008
Copper	NA	NA	--	D	IRIS	12/2/2011
Iron	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	9/11/2006
Manganese	NA	NA	--	D	IRIS	12/2/2011
Thallium	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/8/2010
Vanadium[4]	8.3E-03	$(\mu g/m^3)^{-1}$	--	suggestive evidence of carcinogenic potential	PPRTV	4/30/2008

[1] Idenitified as a mutagen on the Regional Screening Level (RSL) Table, June 2011, http://www.epa.gov/region09/waste/sfund/prg/index.html
[2] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/ Date shown for other sources is the publication date.
[3] based on inhalation unit risk of chromium (VI)
[4] based on vanadium pentoxide

Definition:
Cal/EPA = California Environmental Protection Agency
IRIS = Integrated Risk Information System
M = mutagen
NA = not available
$\mu g/m^3$ = microgram per cubic meter
PPRTV = Provisional Peer Reviewed Toxicity Value

EPA Weight of Evidence (EPA 1986, EPA 1996):
A - Human Carcinogen
B1 - Probable human carcinogen
indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen

EPA Weight of Evidence Narrative (EPA 2005):
Carcinogenic to human
Likely to be carcinogenic to humans
Suggestive evidence of carcinogenic potential
Inadequate information to assess carcinogenic potential
Not likely to be carcinogenic to humans

IARC Classification:
2A - The agent is probably carcinogenic to humans

TABLE 6-1
SUMMARY OF CANCER RISKS AND NONCANCER HEALTH HAZARDS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Receptor	Cancer Risk[1]		Noncancer Hazard Index[2]			
			RME		CTE	
	RME	CTE	Total	Organ/Effect (Risk Driver)	Total	Organ/Effect (Risk Driver)
Current Land-Use						
Commercial/Industrial Worker						
Former Sugar Mill	4×10^{-5}	--	**5**	HI Kidney: 5 (vanadium in groundwater) HI Respiratory System: 4 (vanadium in groundwater)	**4**	HI Kidney: 3 (vanadium in groundwater) HI Respiratory System: 3 (vanadium in groundwater)
Puerto Rico Beverage	4×10^{-5}	--	**5**	HI Kidney: 4 (vanadium in groundwater) HI Respiratory System: 4 (vanadium in groundwater)	**3**	HI Kidney: 3 (vanadium in groundwater) HI Respiratory System: 3 (vanadium in groundwater)
Trespasser						
Former Sugar Mill	9×10^{-7}	--	0.8		--	
Puerto Rico Beverage	1×10^{-6}	--	0.7		--	
Resident [3]						
Former Sugar Mill	**2×10^{-4}**	8×10^{-5}	**36**	HI Kidney: 32 (vanadium in soil and groundwater) HI Respiratory System: 30 (vanadium in soil and groundwater) HI Lung: 2 (arsenic and chromium in soil and groundwater GI Tract: 2 (iron in soil and groundwater)	**16**	HI Kidney: 14 (vanadium in soil and groundwater) HI Respiratory System: 13 (vanadium in soil and groundwater)
Recreational User						
Maunabo River	9×10^{-7}	--	**1**		**--**	
Future Land-Use						
Commercial/Industrial Worker						
Former Sugar Mill	4×10^{-5}	--	**5**	HI Kidney: 5 (vanadium in groundwater) HI Respiratory System: 4 (vanadium in groundwater)	**4**	HI Kidney: 3 (vanadium in groundwater) HI Respiratory System: 3 (vanadium in groundwater)
Puerto Rico Beverage	4×10^{-5}	--	**5**	HI Kidney: 4 (vanadium in groundwater) HI Respiratory System: 4 (vanadium in groundwater)	**3**	HI Kidney: 3 (vanadium in groundwater) HI Respiratory System: 3 (vanadium in groundwater)
Trespasser						
Former Sugar Mill	9×10^{-7}	--	0.8		**--**	
Puerto Rico Beverage	1×10^{-6}	--	0.7		**--**	
Resident [3]						
Former Sugar Mill	**2×10^{-4}**	8×10^{-5}	**36**	HI Kidney: 32 (vanadium in soil and groundwater) HI Respiratory System: 30 (vanadium in soil and groundwater) HI Lung: 2 (arsenic and chromium in soil and groundwater GI Tract: 2 (iron in soil and groundwater)	**16**	HI Kidney: 14 (vanadium in soil and groundwater) HI Respiratory System: 13 (vanadium in soil and groundwater)
Puerto Rico Beverage	**2×10^{-4}**	8×10^{-5}	**34**	HI Kidney: 31 (vanadium in soil and groundwater) HI Respiratory System: 29 (vanadium in soil and groundwater) HI Lung: 2 (arsenic and chromium in soil and groundwater)	**15**	HI Kidney: 13 (vanadium in soil and groundwater) HI Respiratory System: 13 (vanadium in soil and groundwater)
Maunabo River	2×10^{-5}	--	0.007		**--**	
Construction Worker						
Former Sugar Mill	2×10^{-7}	--	**2**	HI Kidney: 2 (vanadium in soil and groundwater) HI Respiratory System: 2 (vanadium in soil and groundwater)	**--**	
Puerto Rico Beverage	8×10^{-8}	--	**2**	HI Kidney: 2 (vanadium in soil and groundwater) HI Respiratory System: 2 (vanadium in soil and groundwater)	**--**	
Recreational User						
Maunabo River	9×10^{-7}	--	**1**		**--**	

RME = Reasonable Maximum Exposure
CTE = Central Tendency Exposure
[1] EPA's target range = 1×10^{-6} to 1×10^{-4}
[2] EPA's threshold = unity (1)
[3] For residents, carcinogenic risk is based on age-adjusted scenario and non-carcinogenic hazard index is based on child exposure scenario.

Figures

C:\IMS\GIS\Maunabo\GIS_projects\public_supply_wells.mxd

Public Supply Wells

N

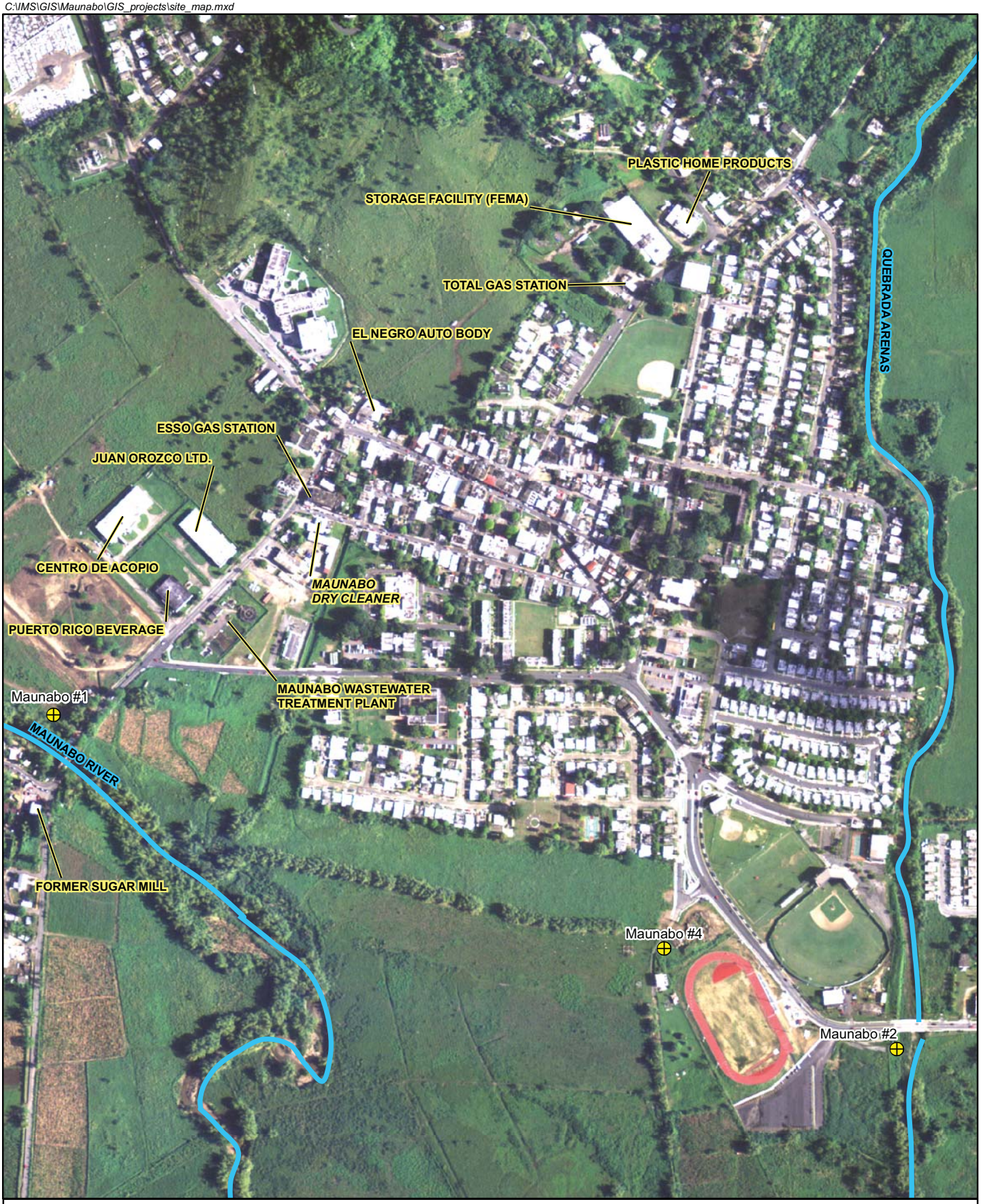
0 2,000 4,000 Feet

CDM Smith

Figure 2-1
Site Location Map
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

R2-0002136

C:\IMS\GIS\Maunabo\GIS_projects\site_map.mxd



Gas Station — Location of Potential Source
(Italics - Not Investigated by EPA SAT2)

N

0 250 500 1,000 Feet

CDM Smith

Figure 2-2
Site Map
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

R2-0002137

Legend

Maunabo #1 Public Supply Wells

PRB-SB1 Soil Boring

CDM Smith

N

0 50 100 200 300 400 Feet

Figure 3-1
Soil Sampling Location
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

R2-0002138

Legend

- Maunabo #1 Public Supply Wells
- MW- AD Monitoring Wells
- Background Monitoring Wells

CDM Smith

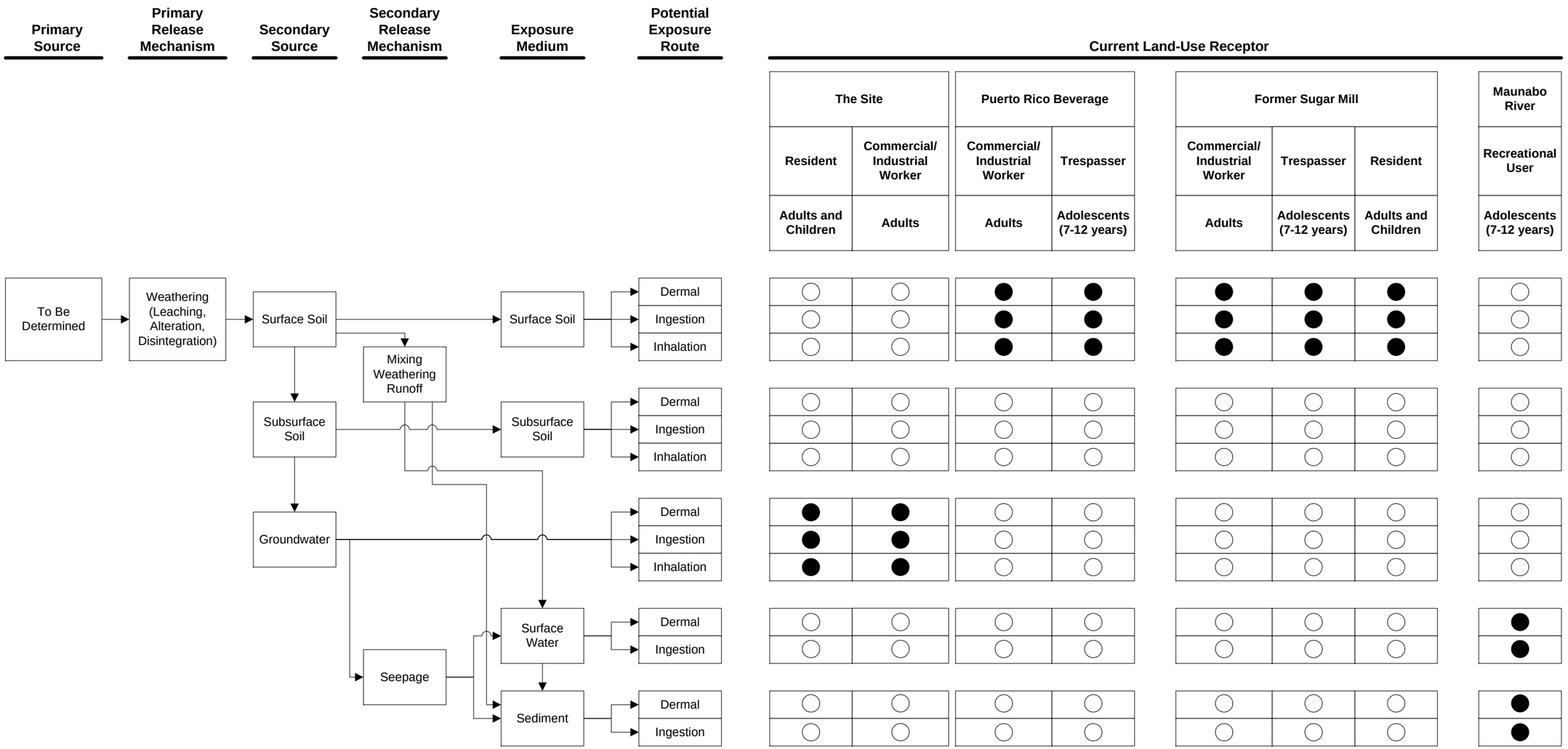
N

0 110 220 440 660 880 Feet

Figure 3-2
Monitoring Well Location Map
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

R2-0002139

Figure 3-3
Surface Water and Sediment Location
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico



Legend:

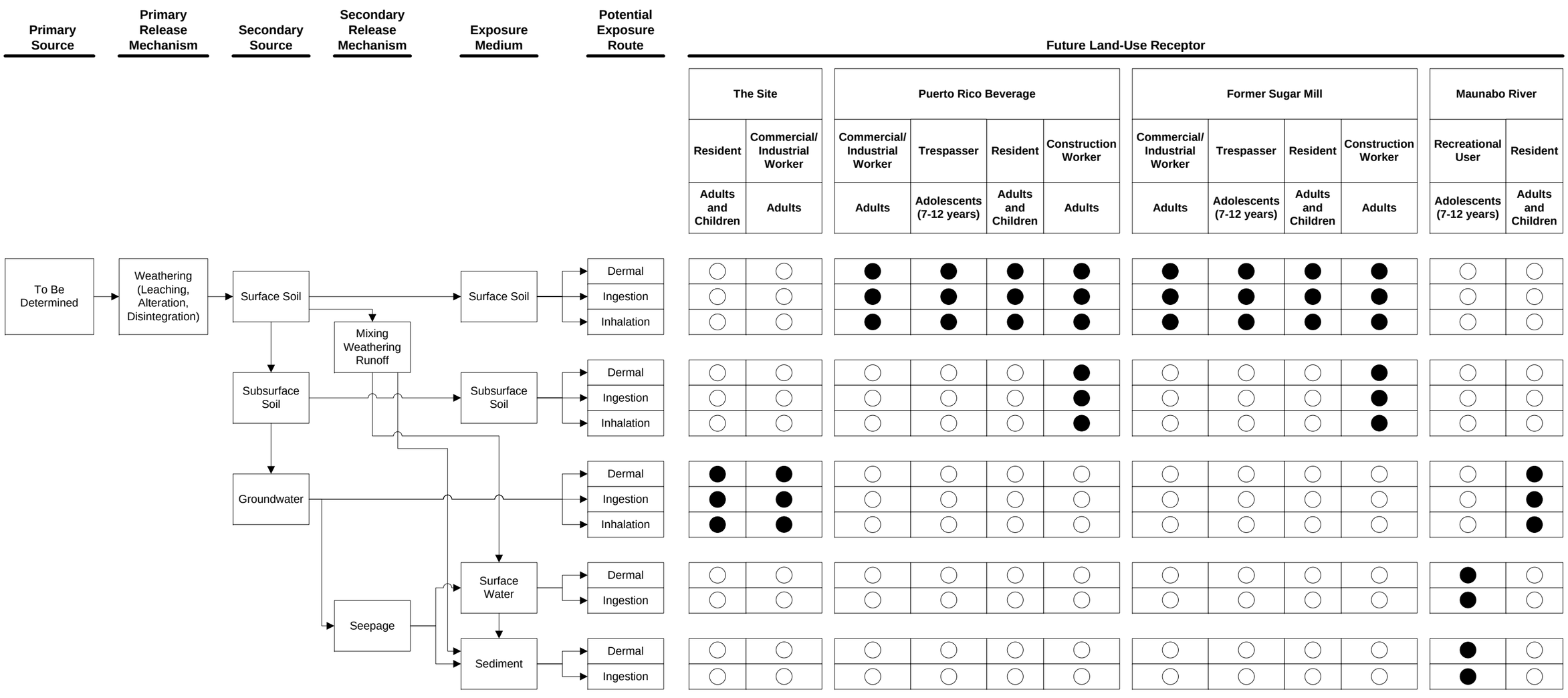
- ● complete exposure pathway
- ○ incomplete/insignificant exposure pathway

The site = Maunabo Groundwater Contamination Site, which include Former Sugar Mill and Puerto Rico Beverage Areas

CDM Smith

Figure 4-1
Conceptual Site Model
Current Land-Use Scenario
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

R2-0002141



Legend:

- ● complete exposure pathway
- ○ incomplete/insignificant exposure pathway

The site = Maunabo Groundwater Contamination Site, which include Former Sugar Mill and Puerto Rico Beverage Areas

CDM Smith

Figure 4-2
Conceptual Site Model
Future Land-Use Scenario
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

R2-0002142

Appendix A

List of Samples Used in the Risk Assessment

Appendix A Contents
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

TABLE A-1
SOIL SAMPLE LIST
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Location	Sample ID	Sample Depth (feet)	Collection Date	Comment	Use In Risk Assessment
Former Sugar Mill					
Surface Soil					
FSM-SB-1	FSM-SB-1-1	0 - 2	1/4/2011		Y
FSM-SB-2	FSM-SB-2-1	0 - 2	1/4/2011		Y
FSM-SB-3	FSM-SB-3-1	0 - 2	1/4/2011		Y
FSM-SB-4	FSM-SB-4-1	0 - 2	1/4/2011		Y
FSM-SB-5	FSM-SB-5-1	0 - 2	1/4/2011		Y
FSM-SB-6	FSM-SB-6-1	0 - 2	1/4/2011		Y
				Total Surface Soil Samples	**6**
Subsurface Soil					
FSM-SB-1	FSM-SB-1-2	2 - 4	1/4/2011		Y
FSM-SB-1	FSM-SB-1-3	4 - 8	1/4/2011		Y
FSM-SB-1	FSM-SB-1-4	8 - 12	1/4/2011		Y
FSM-SB-2	FSM-SB-2-2	2 - 4	1/4/2011		Y
FSM-SB-2	FSM-SB-2-3	4 - 8	1/4/2011		Y
FSM-SB-2	FSM-SB-2-4	8 - 12	1/4/2011		Y
FSM-SB-3	FSM-SB-3-2	2 - 4	1/4/2011		Y
FSM-SB-3	FSM-SB-3-3	4 - 8	1/4/2011		Y
FSM-SB-3	FSM-SB-3-3DUP	4 - 8	1/4/2011	Duplicate of FSM-SB-3-3	N [1]
FSM-SB-3	FSM-SB-3-4	8 - 12	1/4/2011		Y
FSM-SB-4	FSM-SB-4-2	2 - 4	1/4/2011		Y
FSM-SB-4	FSM-SB-4-3	4 - 8	1/4/2011		Y
FSM-SB-4	FSM-SB-4-4	8 - 12	1/4/2011		Y
FSM-SB-5	FSM-SB-5-2	2 - 4	1/4/2011		Y
FSM-SB-5	FSM-SB-5-3	4 - 8	1/4/2011		Y
FSM-SB-5	FSM-SB-5-4	8 - 12	1/4/2011		Y
FSM-SB-6	FSM-SB-6-2	2 - 4	1/4/2011		Y
FSM-SB-6	FSM-SB-6-3	4 - 8	1/4/2011		Y
FSM-SB-6	FSM-SB-6-4	8 - 12	1/4/2011		Y
				Total Surface and Subsurface Soil Samples	**24**
Puerto Rico Beverage					
Surface Soil					
PRB-SB-1	PRB-SB-1-1	0 - 2	1/3/2011		Y
PRB-SB-2	PRB-SB-2-1	0 - 2	1/3/2011		Y
PRB-SB-3	PRB-SB-3-1	0 - 2	1/3/2011		Y
PRB-SB-4	PRB-SB-4-1	0 - 2	1/3/2011		Y
PRB-SB-5	PRB-SB-5-1	0 - 2	1/5/2011		Y
PRB-SB-6	PRB-SB-6-1	0 - 2	1/5/2011		Y
				Total Surface Soil Samples	**6**
Subsurface Soil					
PRB-SB-1	PRB-SB-1-2	2 - 4	1/3/2011		Y
PRB-SB-1	PRB-SB-1-3	4 - 8	1/3/2011		Y
PRB-SB-1	PRB-SB-1-4	8 - 12	1/3/2011		Y
PRB-SB-2	PRB-SB-2-2	2 - 4	1/3/2011		Y
PRB-SB-2	PRB-SB-2-2DUP	2 - 4	1/3/2011	Duplicate of PRB-SB-2-2	N [1]
PRB-SB-2	PRB-SB-2-3	4 - 8	1/3/2011		Y
PRB-SB-2	PRB-SB-2-4	8 - 12	1/3/2011		Y
PRB-SB-3	PRB-SB-3-2	2 - 4	1/3/2011		Y
PRB-SB-3	PRB-SB-3-3	4 - 8	1/3/2011		Y
PRB-SB-3	PRB-SB-3-4	8 - 12	1/3/2011		Y
PRB-SB-4	PRB-SB-4-2	2 - 4	1/3/2011		Y
PRB-SB-4	PRB-SB-4-3	4 - 8	1/3/2011		Y
PRB-SB-4	PRB-SB-4-4	8 - 12	1/3/2011		Y
PRB-SB-5	PRB-SB-5-2	2 - 4	1/5/2011		Y
PRB-SB-5	PRB-SB-5-2DUP	2 - 4	1/5/2011	Duplicate of PRB-SB-5-2	N [1]
PRB-SB-6	PRB-SB-6-2	2 - 4	1/5/2011		Y
				Total Surface and Subsurface Soil Samples	**20**

Y = Yes. Used in risk assessment.
N = No. Not used in risk assessment.
Note:
[1] Duplicate samples are collected for quality assurance/quality control purposes, but are not included in risk assessment evaluations.

TABLE A-2
GROUNDWATER SAMPLE LIST
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Location	Sample ID	Collection Date	Comment	Use In Risk Assessment
MAUNABO-1	M1-INF	9/24/2010		Y
MAUNABO-1	MAUNABO-1-R1	3/2/2011		Y
MAUNABO-1	MAUNABO-1-R1-DUP	3/2/2011	Duplicate of MAUNABO-1-R1	N (1)
MAUNABO-1	MAUNABO-1-R2	6/8/2011		Y
MAUNABO-1	MAUNABO-1-R2-DUP	6/8/2011	Duplicate of MAUNABO-1-R2	N (1)
MAUNABO-2	MAUNABO-2-R1	3/4/2011		Y
MAUNABO-2	MAUNABO-2-R2	6/8/2011		Y
MAUNABO-3	MAUNABO-3-R1	3/7/2011		Y
MAUNABO-3	MAUNABO-3-R2	6/9/2011		Y
MAUNABO-4	MAUNABO-4-R1	3/3/2011		Y
MAUNABO-4	MAUNABO-4-R2	6/9/2011		Y
MW-AD	MW-AD-R1	3/2/2011		Y
MW-AD	MW-AD-R2	6/7/2011		Y
MW-AS	MW-AS-R1	3/2/2011		Y
MW-AS	MW-AS-R2	6/7/2011		Y
MW-B	MW-B-R1	3/2/2011		Y
MW-B	MW-B-R2	6/9/2011		Y
MW-C	MW-C-R1	3/8/2011		Y
MW-C	MW-C-R2	6/10/2011		Y
MW-D	MW-D-R1	3/8/2011	Background	N (2)
MW-D	MW-D-R2	6/8/2011	Background	N (2)
MW-E	MW-E-R1	3/7/2011		Y
MW-E	MW-E-R2	6/9/2011		Y
MW-FD	MW-FD-R1	3/7/2011		Y
MW-FD	MW-FD-R1-DUP	3/7/2011	Duplicate of MW-FD-R1	N (1)
MW-FD	MW-FD-R2	6/7/2011		Y
MW-FD	MW-FD-R2-DUP	6/7/2011	Duplicate of MW-FD-R2	N (1)
MW-FS	MW-FS-R1	3/7/2011		Y
MW-FS	MW-FS-R2	6/7/2011		Y
MW-H	MW-H-R1	3/4/2011	Background	N (2)
MW-H	MW-H-R2	6/10/2011	Background	N (2)
MW-I	MW-I-R1	3/3/2011		Y
MW-I	MW-I-R2	6/8/2011		Y
MW-J	MW-J-R1	3/3/2011		Y
MW-J	MW-J-R2	6/8/2011		Y
MW-K	MW-K-R1	3/3/2011		Y
MW-K	MW-K-R2	6/10/2011		Y
MW-L	MW-L-R1	3/4/2011		Y
MW-L	MW-L-R2	6/10/2011		Y
MW-M	MW-M-R1	3/4/2011		Y
MW-M	MW-M-R2	6/9/2011		Y
MW-N	MW-N-R1	3/4/2011		Y
MW-N	MW-N-R2	6/9/2011		Y
MW-O	MW-O-R1	3/8/2011	Background	N (2)
MW-O	MW-O-R2	6/8/2011	Background	N (2)
			Total Groundwater Samples	**35**

Y = Yes. Used in risk assessment.
N = No. Not used in risk assessment.
Notes:
(1) Duplicate samples are collected for quality assurance/quality control purposes, but are not included in risk assessment evaluations.
(2) Background samples are used to establish background levels. They are not included in risk assessment evaluations.

TABLE A-3
SURFACE WATER SAMPLE LIST
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Location	Sample ID	Collection Date	Comment	Use In Risk Assessment
SW-01	SW-01	5/10/2011	Background	N [1]
SW-02	SW-02	5/10/2011		Y
SW-03	SW-03	5/10/2011		Y
SW-03	SW-03-DUP	5/10/2011	Duplicate of SW-03	N [2]
SW-04	SW-04	5/10/2011		Y
SW-05	SW-05	5/9/2011		Y
SW-06	SW-06	5/9/2011		Y
SW-07	SW-07	5/9/2011		Y
		Total Surface Water Samples		**6**

Y = Yes. Used in risk assessment.
N = No. Not used in risk assessment.
Notes:
[1] Background samples are used to establish background levels. They are not included in risk assessment evaluations.
[2] Duplicate samples are collected for quality assurance/quality control purposes, but are not included in risk assessment evaluations.

TABLE A-4
SEDIMENT SAMPLE LIST
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Location	Sample ID	Sample Depth	Collection Date	Comment	Use In Risk Assessment
SD-01	SD-01	0 - 6	5/10/2011	Background	N [1]
SD-02	SD-02	0 - 6	5/10/2011		Y
SD-03	SD-03	0 - 6	5/10/2011		Y
SD-03	SD-03-DUP	0 - 6	5/10/2011	Duplicate of SD-03	N [2]
SD-04	SD-04	0 - 6	5/10/2011		Y
SD-05	SD-05	0 - 6	5/9/2011		Y
SD-06	SD-06	0 - 6	5/9/2011		Y
SD-07	SD-07	0 - 6	5/9/2011		Y
				Total Sediment Samples	**6**

Y = Yes. Used in risk assessment.
N = No. Not used in risk assessment.
Notes:
[1] Background samples are used to establish background levels. They are not included in risk assessment evaluations.
[2] Duplicate samples are collected for quality assurance/quality control purposes, but are not included in risk assessment evaluations.

Appendix B

RAGS D Tables – RME Scenario

Appendix B Contents
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

TABLE B-1
SELECTION OF EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor (Age)	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Soil	Surface Soil	Former Sugar Mill	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while at their residence.
						Ingestion	Quant	
						Inhalation	Quant	
			Puerto Rico Beverage	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
	Groundwater	Groundwater	Groundwater	Commercial/ Industrial Worker	Adult	Dermal	Quant	Groundwater is used as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents use groundwater as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
		Indoor Air	Indoor Air	Commercial/ Industrial Worker	Adult	Inhalation	Qual	Workers and residents may be exposed to contaminants in indoor air via vapor intrusion pathway from groundwater. Groundwater concentration is screened against the groundwater for indoor air screening level in the risk assessment.
				Resident	Adult and Child (0-6 yrs)	Inhalation	Qual	

TABLE B-1
SELECTION OF EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor (Age)	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Surface Water	Surface Water	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in surface water through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
	Sediment	Sediment	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in sediment through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
Future	Soil	Surface Soil	Former Sugar Mill	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while at their residence.
						Ingestion	Quant	
						Inhalation	Quant	
			Puerto Rico Beverage	Commercial/ Industrial Worker	Adult	Dermal	Quant	Workers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Trespasser	Adolescent (7-12 yrs)	Dermal	Quant	Trespassers may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may come into contact with contaminants in surface soil and/or inhale fugitive dust and volatile chemicals while at their residence.
						Ingestion	Quant	
						Inhalation	Quant	

TABLE B-1
SELECTION OF EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor (Age)	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Soil	Surface and Subsurface Soil	Former Sugar Mill	Construction Worker	Adult	Dermal	Quant	Construction workers may come into contact with contaminants in soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
			Puerto Rico Beverage	Construction Worker	Adult	Dermal	Quant	Construction workers may come into contact with contaminants in soil and/or inhale fugitive dust and volatile chemicals while working at the site.
						Ingestion	Quant	
						Inhalation	Quant	
	Groundwater	Groundwater	Groundwater	Commercial/ Industrial Worker	Adult	Dermal	Quant	Groundwater is used as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents use groundwater as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
		Indoor Air	Indoor Air	Commercial/ Industrial Worker	Adult	Inhalation	Qual	Workers and residents may be exposed to contaminants in indoor air via vapor intrusion pathway from groundwater. Groundwater concentration is screened against the groundwater for indoor air screening level in the risk assessment.
				Resident	Adult and Child (0-6 yrs)	Inhalation	Qual	
	Surface Water	Surface Water	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in surface water through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	
				Resident	Adult and Child (0-6 yrs)	Dermal	Quant	Residents may use surface water as drinking water.
						Ingestion	Quant	
						Inhalation	Quant	
	Sediment	Sediment	Maunabo River	Recreational User	Adolescent (7-12 yrs)	Dermal	Quant	Recreational users may come into contact with contaminants in sediment through incidental ingestion of and dermal contact while visiting the site.
						Ingestion	Quant	
						Inhalation	Quant	

Quant = Quantitative risk analysis performed
Qual = Qualitative risk analysis performed

TABLE B-2.1a

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil - Former Sugar Mill

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface Soil	**Semi-volatile Organic Compounds**														
	91-57-6	2-Methylnaphthalene	14 J	14 J	µg/kg	FSM-SB-3	1 / 6	85 - 85	14	NA	31000 n	15000	SSL[4]	No	BSL
	208-96-8	Acenaphthylene	11 J	13 J	µg/kg	FSM-SB-3	2 / 6	85 - 85	13	NA	340000 n[5]	NA	SSL[4]	No	BSL
	120-12-7	Anthracene	5.3 J	5.3 J	µg/kg	FSM-SB-3	1 / 6	85 - 85	5.3	NA	1700000 n	7200000	SSL[4]	No	BSL
	56-55-3	Benzo(a)anthracene	8.2 J	78 J	µg/kg	FSM-SB-3	4 / 6	85 - 85	78	NA	150 c	NA	SSL[4]	No	BSL
	50-32-8	**Benzo(a)pyrene**	**7.9 J**	**76 J**	**µg/kg**	**FSM-SB-3**	**4 / 6**	**85 - 85**	**76**	**NA**	**15 c**	**4800**	**SSL[4]**	**Yes**	**ASL**
	205-99-2	Benzo(b)fluoranthene	8.2 J	89 J	µg/kg	FSM-SB-3	4 / 6	85 - 85	89	NA	150 c	NA	SSL[4]	No	BSL
	191-24-2	Benzo(g,h,i)perylene	6.3 J	56 J	µg/kg	FSM-SB-3	5 / 6	85 - 85	56	NA	170000 n[6]	NA	SSL[4]	No	BSL
	207-08-9	Benzo(k)fluoranthene	5.5 J	64 J	µg/kg	FSM-SB-3	4 / 6	85 - 85	64	NA	1500 c	NA	SSL[4]	No	BSL
	85-68-7	Butylbenzylphthalate	13 J	120	µg/kg	FSM-SB-6	6 / 6	85 - 85	120	NA	260000 c	10200	SSL[4]	No	BSL
	86-74-8	Carbazole	4.2 J	4.2 J	µg/kg	FSM-SB-3	1 / 6	85 - 85	4.2	NA	NA	NA	SSL[4]	No	NTX
	218-01-9	Chrysene	10 J	96 J	µg/kg	FSM-SB-3	4 / 6	85 - 85	96	NA	15000 c	NA	SSL[4]	No	BSL
	53-70-3	**Dibenzo(a,h)anthracene**	**12 J**	**18 J**	**µg/kg**	**FSM-SB-3**	**2 / 6**	**85 - 85**	**18**	**NA**	**15 c**	**NA**	**SSL[4]**	**Yes**	**ASL**
	206-44-0	Fluoranthene	11 J	130	µg/kg	FSM-SB-3	4 / 6	85 - 85	130	NA	230000 n	3200000	SSL[4]	No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	7 J	62 J	µg/kg	FSM-SB-3	4 / 6	85 - 85	62	NA	150 c	NA	SSL[4]	No	BSL
	91-20-3	Naphthalene	12 J	12 J	µg/kg	FSM-SB-3	1 / 6	85 - 85	12	NA	3600 c	9.4	SSL[4]	No	BSL
	85-01-8	Phenanthrene	5.5 J	81 J	µg/kg	FSM-SB-3	4 / 6	85 - 85	81	NA	1700000 n[7]	NA	SSL[4]	No	BSL
	129-00-0	Pyrene	5.2 J	140	µg/kg	FSM-SB-3	5 / 6	85 - 85	140	NA	170000 n	2400000	SSL[4]	No	BSL
	Pesticides/Polychlorinated Biphenyls														
	72-55-9	4,4'-DDE	5.7 J	5.7 J	µg/kg	FSM-SB-3	1 / 6	0.17 - 0.17	5.7	NA	1400 c	920	SSL[4]	No	BSL
	50-29-3	4,4'-DDT	9.1	9.1	µg/kg	FSM-SB-3	1 / 6	0.17 - 0.17	9.1	NA	1700 c	1340	SSL[4]	No	BSL
	309-00-2	Aldrin	0.84	0.84	µg/kg	FSM-SB-2	1 / 6	0.085 - 0.085	0.84	NA	29 c	13	SSL[4]	No	BSL
	5103-71-9	Alpha-Chlordane	0.19 NJ	0.19 NJ	µg/kg	FSM-SB-6	1 / 6	0.085 - 0.085	0.19	NA	1600 c[8]	260	SSL[4]	No	BSL
	60-57-1	Dieldrin	0.2	3.2	µg/kg	FSM-SB-2	2 / 6	0.17 - 0.17	3.2	NA	30 c	3.4	SSL[4]	No	BSL
	1031-07-8	Endosulfan Sulfate	0.44 NJ	0.44 NJ	µg/kg	FSM-SB-6	1 / 6	0.17 - 0.17	0.44	NA	37000 n[9]	60000	SSL[4]	No	BSL
	5103-74-2	Gamma-Chlordane	0.52	0.52	µg/kg	FSM-SB-2	1 / 6	0.085 - 0.085	0.52	NA	1600 c[8]	260	SSL[4]	No	BSL
	Inorganics														
	7429-90-5	**Aluminum**	**5140**	**15800**	**mg/kg**	**FSM-SB-4**	**6 / 6**	**20 - 20**	**15800**	**NA**	**7700 n**	**1100000**	**SSL[4]**	**Yes**	**ASL**
	7440-36-0	Antimony	0.016 J	0.14 J	mg/kg	FSM-SB-2	4 / 6	1 - 1	0.14	NA	3.1 n	13.2	SSL[4]	No	BSL
	7440-38-2	**Arsenic**	**0.84 J**	**4.6**	**mg/kg**	**FSM-SB-3**	**6 / 6**	**1 - 1**	**4.6**	**NA**	**0.39 c**	**0.026**	**SSL[4]**	**Yes**	**ASL**
	7440-39-3	Barium	53.5	192	mg/kg	FSM-SB-4	6 / 6	20 - 20	192	NA	1500 n	6000	SSL[4]	No	BSL
	7440-43-9	Cadmium	0.13 J	2.5	mg/kg	FSM-SB-4	6 / 6	0.5 - 0.5	2.5	NA	7 n	28	SSL[4]	No	BSL
	7440-70-2	Calcium	2660	65200	mg/kg	FSM-SB-5	6 / 6	500 - 500	65200	NA	NA	NA	SSL[4]	No	NUT
	7440-47-3	**Chromium**	**3**	**17.1**	**mg/kg**	**FSM-SB-4**	**6 / 6**	**1 - 1**	**17.1**	**NA**	**0.29 c[10]**	**3600000**	**SSL[4]**	**Yes**	**ASL**
	7440-48-4	**Cobalt**	**3 J**	**10.5**	**mg/kg**	**FSM-SB-4**	**6 / 6**	**5 - 5**	**10.5**	**NA**	**2.3 n**	**9.8**	**SSL[4]**	**Yes**	**ASL**
	7440-50-8	Copper	22.2	105	mg/kg	FSM-SB-4	6 / 6	2.5 - 2.5	105	NA	310 n	1020	SSL[4]	No	BSL
	57-12-5	Cyanide	0.13 J	0.37 J	mg/kg	FSM-SB-1	6 / 6	0.5 - 0.5	0.37	NA	160 n	148	SSL[4]	No	BSL
	7439-89-6	**Iron**	**16600**	**41800**	**mg/kg**	**FSM-SB-4**	**6 / 6**	**10 - 10**	**41800**	**NA**	**5500 n**	**12800**	**SSL[4]**	**Yes**	**ASL**
	7439-92-1	Lead	2.2	710	mg/kg	FSM-SB-4	6 / 6	1 - 1	710	NA	400 n[11]	280	SSL[4]	No	[15]
	7439-95-4	Magnesium	1610	3610	mg/kg	FSM-SB-4	6 / 6	500 - 500	3610	NA	NA	NA	SSL[4]	No	NUT
	7439-96-5	**Manganese**	**221**	**547**	**mg/kg**	**FSM-SB-4**	**6 / 6**	**1.5 - 1.5**	**547**	**NA**	**180 n**	**1140**	**SSL[4]**	**Yes**	**ASL**
	7439-97-6	Mercury	0.026 J	0.67 J	mg/kg	FSM-SB-4	6 / 6	0.1 - 0.1	0.67	NA	2.3 n[12]	NA	SSL[4]	No	BSL
	7440-02-0	Nickel	1.8 J	19.2	mg/kg	FSM-SB-4	6 / 6	4 - 4	19.2	NA	150 n[13]	960	SSL[4]	No	BSL

TABLE B-2.1a

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil - Former Sugar Mill

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface Soil	7440-09-7	Potassium	560 J	1650	mg/kg	FSM-SB-4	6 / 6	500 - 500	1650	NA	NA	NA	SSL[4]	No	NUT
	7440-22-4	Silver	0.92 J	3.5	mg/kg	FSM-SB-4	3 / 6	1 - 1	3.5	NA	39 n	32	SSL[4]	No	BSL
	7440-23-5	Sodium	106 J	272 J	mg/kg	FSM-SB-3	6 / 6	500 - 500	272	NA	NA	NA	SSL[4]	No	NUT
	7440-28-0	Thallium	0.0094 J	0.05 J	mg/kg	FSM-SB-3	6 / 6	0.5 - 0.5	0.05	NA	0.078 n	0.52	SSL[4]	No	BSL
	7440-62-2	**Vanadium**	**24.3**	**69.3**	**mg/kg**	**FSM-SB-3**	**6 / 6**	**5 - 5**	**69.3**	**NA**	**39 n[14]**	**3600**	**SSL[4]**	**Yes**	**ASL**
	7440-66-6	Zinc	33.5	742	mg/kg	FSM-SB-4	6 / 6	6 - 6	742	NA	2300 n	13600	SSL[4]	No	BSL

[1] Maximum detected concentration used for screening

[2] Screened against Regional Screening Levels, November 2011, for residential soil, adjusted to a cancer risk of $1\times1(^{6}$ and hazard quotient of 0.1. http://www.epa.gov/region09/waste/sfund/prg/index.html

[3] Rationale Codes:

Selection Reason: ASL = above screening level

Deletion Reason: BSL = below screening level

NUT = essential nutrient

NTX = no toxicity information available

[4] Potential ARAR/TBC value from Regional Screening Levels, June 2011, for protection of groundwater soil screening levels, based on a dilution factor of 20.

[5] screening value for acenaphthene

[6] screening value for pyrene

[7] screening value for anthracene

[8] screening value for chlordane

[9] screening value for endosulfan

[10] screening value for chromium VI

[11] OSWER screening value for residential soil

[12] screening value for mercuric chloride (and other mercury salts)

[13] screening value for nickel soluble salts

[14] screening value for vanadium and compounds

[15] Mean concentration of lead is less than the screening criteria.

NA = not available

ND = not detected

n = screening toxicity value based on noncancer effects

c = screening toxicity value based on cancer effects

SSL = soil screening level

COPC = chemical of potential concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J = qualifier for estimated value

NJ = qualifier for tentatively identified and estimated value

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

4,4'-DDE = p,p'-dichlorodiphenyldichloroethylene

4,4'-DDT = p,p'-dichlorodiphenyltrichloroethane

TABLE B-2.1b

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil - Puerto Rico Beverage

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface Soil	**Volatile Organic Compounds**														
	78-93-3	2-Butanone	5.2 J	5.2 J	µg/kg	PRB-SB-3	1 / 6	10 - 10	5.2	NA	2800000 n	30000	SSL[4]	No	BSL
	67-64-1	Acetone	31	31	µg/kg	PRB-SB-3	1 / 6	10 - 10	31	NA	6100000 n	90000	SSL[4]	No	BSL
	Semi-volatile Organic Compounds														
	99-09-2	3-Nitroaniline	54 J	54 J	µg/kg	PRB-SB-1	1 / 6	170 - 170	54	NA	NA	NA	SSL[4]	No	NTX
	56-55-3	Benzo(a)anthracene	3.9 J	3.9 J	µg/kg	PRB-SB-6	1 / 6	85 - 85	3.9	NA	150 c	NA	SSL[4]	No	BSL
	50-32-8	Benzo(a)pyrene	4.4 J	4.4 J	µg/kg	PRB-SB-6	1 / 6	85 - 85	4.4	NA	15 c	4800	SSL[4]	No	BSL
	205-99-2	Benzo(b)fluoranthene	4.4 J	4.4 J	µg/kg	PRB-SB-6	1 / 6	85 - 85	4.4	NA	150 c	NA	SSL[4]	No	BSL
	191-24-2	Benzo(g,h,i)perylene	4 J	4 J	µg/kg	PRB-SB-6	1 / 6	85 - 85	4	NA	170000 n[5]	NA	SSL[4]	No	BSL
	117-81-7	Bis(2-Ethylhexyl)Phthalate	1100	1100	µg/kg	PRB-SB-5	1 / 6	85 - 85	1100	NA	35000 c	22000	SSL[4]	No	BSL
	85-68-7	Butylbenzylphthalate	39 J	200	µg/kg	PRB-SB-5	3 / 6	85 - 85	200	NA	260000 c	10200	SSL[4]	No	BSL
	218-01-9	Chrysene	4.6 J	6.4 J	µg/kg	PRB-SB-5	2 / 6	85 - 85	6.4	NA	15000 c	NA	SSL[4]	No	BSL
	206-44-0	Fluoranthene	4.8 J	4.8 J	µg/kg	PRB-SB-6	1 / 6	85 - 85	4.8	NA	230000 n	3200000	SSL[4]	No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	4 J	4 J	µg/kg	PRB-SB-6	1 / 6	85 - 85	4	NA	150 c	NA	SSL[4]	No	BSL
	129-00-0	Pyrene	5.5 J	5.5 J	µg/kg	PRB-SB-6	1 / 6	85 - 85	5.5	NA	170000 n	2400000	SSL[4]	No	BSL
	Pesticides/Polychlorinated Biphenyls														
	72-55-9	4,4'-DDE	0.31	1.3 NJ	µg/kg	PRB-SB-5	2 / 6	0.17 - 0.17	1.3	NA	1400 c	920	SSL[4]	No	BSL
	50-29-3	4,4'-DDT	0.98 J	0.98 J	µg/kg	PRB-SB-5	1 / 6	0.17 - 0.17	0.98	NA	1700 c	1340	SSL[4]	No	BSL
	5103-71-9	Alpha-Chlordane	4 NJ	4 NJ	µg/kg	PRB-SB-5	1 / 6	0.085 - 0.085	4	NA	1600 c[6]	260	SSL[4]	No	BSL
	5103-74-2	Gamma-Chlordane	1.4	5.6	µg/kg	PRB-SB-5	2 / 6	0.085 - 0.085	5.6	NA	1600 c[6]	260	SSL[4]	No	BSL
	76-44-8	Heptachlor	1.2 NJ	1.2 NJ	µg/kg	PRB-SB-5	1 / 6	0.085 - 0.085	1.2	NA	110 c	24	SSL[4]	No	BSL
	1024-57-3	Heptachlor Epoxide	0.16 J	1.5 J	µg/kg	PRB-SB-5	2 / 6	0.085 - 0.085	1.5	NA	53 c	3	SSL[4]	No	BSL
	Inorganics														
	7429-90-5	**Aluminum**	**7060**	**15700**	**mg/kg**	**PRB-SB-3**	**6 / 6**	**20 - 20**	**15700**	**NA**	**7700 n**	**1100000**	**SSL[4]**	**Yes**	**ASL**
	7440-36-0	Antimony	0.013 J	0.013 J	mg/kg	PRB-SB-6	1 / 6	1 - 1	0.013	NA	3.1 n	13.2	SSL[4]	No	BSL
	7440-38-2	**Arsenic**	**0.43 J**	**2.9**	**mg/kg**	**PRB-SB-5**	**2 / 6**	**1 - 1**	**2.9**	**NA**	**0.39 c**	**0.026**	**SSL[4]**	**Yes**	**ASL**
	7440-39-3	Barium	57.5	106	mg/kg	PRB-SB-3	6 / 6	20 - 20	106	NA	1500 n	6000	SSL[4]	No	BSL
	7440-43-9	Cadmium	0.13 J	1.1	mg/kg	PRB-SB-5	2 / 6	0.5 - 0.5	1.1	NA	7 n	28	SSL[4]	No	BSL
	7440-70-2	Calcium	868	2860	mg/kg	PRB-SB-3	6 / 6	500 - 500	2860	NA	NA	NA	SSL[4]	No	NUT
	7440-47-3	**Chromium**	**1.6**	**27.5**	**mg/kg**	**PRB-SB-5**	**6 / 6**	**1 - 1**	**27.5**	**NA**	**0.29 c[7]**	**3600000**	**SSL[4]**	**Yes**	**ASL**
	7440-48-4	**Cobalt**	**2.1 J**	**7.5**	**mg/kg**	**PRB-SB-3**	**6 / 6**	**5 - 5**	**7.5**	**NA**	**2.3 n**	**9.8**	**SSL[4]**	**Yes**	**ASL**
	7440-50-8	Copper	33.5	107	mg/kg	PRB-SB-5	6 / 6	2.5 - 2.5	107	NA	310 n	1020	SSL[4]	No	BSL
	57-12-5	Cyanide	0.088 J	0.27 J	mg/kg	PRB-SB-5	4 / 6	0.5 - 0.5	0.27	NA	160 n	148	SSL[4]	No	BSL
	7439-89-6	**Iron**	**16400**	**35900**	**mg/kg**	**PRB-SB-1**	**6 / 6**	**10 - 10**	**35900**	**NA**	**5500 n**	**12800**	**SSL[4]**	**Yes**	**ASL**
	7439-92-1	Lead	23.3	83.3	mg/kg	PRB-SB-5	2 / 6	1 - 1	83.3	NA	400 n[8]	280	SSL[4]	No	BSL
	7439-95-4	Magnesium	2060	3170	mg/kg	PRB-SB-1	6 / 6	500 - 500	3170	NA	NA	NA	SSL[4]	No	NUT
	7439-96-5	**Manganese**	**135**	**365**	**mg/kg**	**PRB-SB-6**	**6 / 6**	**1.5 - 1.5**	**365**	**NA**	**180 n**	**1140**	**SSL[4]**	**Yes**	**ASL**
	7439-97-6	Mercury	0.034 J	0.9	mg/kg	PRB-SB-5	6 / 6	0.1 - 0.1	0.9	NA	2.3 n[9]	NA	SSL[4]	No	BSL
	7440-02-0	Nickel	0.32 J	6	mg/kg	PRB-SB-5	6 / 6	4 - 4	6	NA	150 n[10]	960	SSL[4]	No	BSL
	7440-09-7	Potassium	597 J	1290	mg/kg	PRB-SB-2	6 / 6	500 - 500	1290	NA	NA	NA	SSL[4]	No	NUT
	7440-23-5	Sodium	105 J	361 J	mg/kg	PRB-SB-1	6 / 6	500 - 500	361	NA	NA	NA	SSL[4]	No	NUT
	7440-28-0	Thallium	0.021 J	0.039 J	mg/kg	PRB-SB-1	6 / 6	0.5 - 0.5	0.039	NA	0.078 n	0.52	SSL[4]	No	BSL

TABLE B-2.1b

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil - Puerto Rico Beverage

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface Soil	**7440-62-2**	**Vanadium**	**31.9**	**71.8**	**mg/kg**	**PRB-SB-3**	**6 / 6**	**5 - 5**	**71.8**	**NA**	**39 n[11]**	**3600**	**SSL[4]**	**Yes**	**ASL**
	7440-66-6	Zinc	27.4	438	mg/kg	PRB-SB-5	6 / 6	6 - 6	438	NA	2300 n	13600	SSL[4]	No	BSL

[1] Maximum detected concentration used for screening

[2] Screened against Regional Screening Levels, November 2011, for residential soil, adjusted to a cancer risk of 1×1(^{6} and hazard quotient of 0.1. http://www.epa.gov/region09/waste/sfund/prg/index.html

[3] Rationale Codes:

Selection Reason: ASL = above screening level

Deletion Reason: BSL = below screening level

NUT = essential nutrient

NTX = no toxicity information available

[4] Potential ARAR/TBC value from Regional Screening Levels, June 2011, for protection of groundwater soil screening levels, based on a dilution factor of 20.

[5] screening value for pyrene

[6] screening value for chlordane

[7] screening value for chromium VI

[8] OSWER screening value for residential soil

[9] screening value for mercuric chloride (and other mercury salts)

[10] screening value for nickel soluble salts

[11] screening value for vanadium and compounds

NA = not available

ND = not detected

n = screening toxicity value based on noncancer effects

c = screening toxicity value based on cancer effects

SSL = soil screening level

COPC = chemical of potential concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J = qualifier for estimated value

NJ = qualifier for tentatively identified and estimated value

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

4,4'-DDE = p,p'-dichlorodiphenyldichloroethylene

4,4'-DDT = p,p'-dichlorodiphenyltrichloroethane

TABLE B-2.2a

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface/Subsurface Soil - Former Sugar Mill

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface/ Subsurface Soil	**Volatile Organic Compounds**														
	78-93-3	2-Butanone	8.5 J	35	µg/kg	FSM-SB-4	2 / 24	10 - 10	35	NA	2800000 n	30000	SSL[4]	No	BSL
	67-64-1	Acetone	5.2 J	180	µg/kg	FSM-SB-4	6 / 24	10 - 10	180	NA	6100000 n	90000	SSL[4]	No	BSL
	Semi-volatile Organic Compounds														
	91-57-6	2-Methylnaphthalene	5.7 J	14 J	µg/kg	FSM-SB-3	2 / 24	85 - 85	14	NA	31000 n	15000	SSL[4]	No	BSL
	208-96-8	Acenaphthylene	7.9 J	13 J	µg/kg	FSM-SB-3	3 / 24	85 - 85	13	NA	340000 n[5]	NA	SSL[4]	No	BSL
	120-12-7	Anthracene	5.3 J	5.3 J	µg/kg	FSM-SB-3	1 / 24	85 - 85	5.3	NA	1700000 n	7200000	SSL[4]	No	IFD
	100-52-7	Benzaldehyde	10 J	10 J	µg/kg	FSM-SB-2	1 / 24	85 - 85	10	NA	780000 n	16200	SSL[4]	No	IFD
	56-55-3	Benzo(a)anthracene	7.7 J	78 J	µg/kg	FSM-SB-3	7 / 24	85 - 85	78	NA	150 c	NA	SSL[4]	No	BSL
	50-32-8	**Benzo(a)pyrene**	**7.9 J**	**76 J**	**µg/kg**	**FSM-SB-3**	**7 / 24**	**85 - 85**	**76**	**NA**	**15 c**	**4800**	**SSL[4]**	**Yes**	**ASL**
	205-99-2	Benzo(b)fluoranthene	7.2 J	89 J	µg/kg	FSM-SB-3	7 / 24	85 - 85	89	NA	150 c	NA	SSL[4]	No	BSL
	191-24-2	Benzo(g,h,i)perylene	5.6 J	56 J	µg/kg	FSM-SB-3	9 / 24	85 - 85	56	NA	170000 n[6]	NA	SSL[4]	No	BSL
	207-08-9	Benzo(k)fluoranthene	5.5 J	64 J	µg/kg	FSM-SB-3	7 / 24	85 - 85	64	NA	1500 c	NA	SSL[4]	No	BSL
	85-68-7	Butylbenzylphthalate	4.5 J	120	µg/kg	FSM-SB-6	12 / 24	85 - 85	120	NA	260000 c	10200	SSL[4]	No	BSL
	86-74-8	Carbazole	4.2 J	4.2 J	µg/kg	FSM-SB-3	1 / 24	85 - 85	4.2	NA	NA	NA	SSL[4]	No	IFD
	218-01-9	Chrysene	9.4 J	96 J	µg/kg	FSM-SB-3	7 / 24	85 - 85	96	NA	15000 c	NA	SSL[4]	No	BSL
	53-70-3	**Dibenzo(a,h)anthracene**	**8.6 J**	**18 J**	**µg/kg**	**FSM-SB-3**	**3 / 24**	**85 - 85**	**18**	**NA**	**15 c**	**NA**	**SSL[4]**	**Yes**	**ASL**
	206-44-0	Fluoranthene	4.5 J	130	µg/kg	FSM-SB-3	8 / 24	85 - 85	130	NA	230000 n	3200000	SSL[4]	No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	7 J	62 J	µg/kg	FSM-SB-3	7 / 24	85 - 85	62	NA	150 c	NA	SSL[4]	No	BSL
	91-20-3	Naphthalene	12 J	12 J	µg/kg	FSM-SB-3	1 / 24	85 - 85	12	NA	3600 c	9.4	SSL[4]	No	IFD
	87-86-5	Pentachlorophenol	2.1 J	2.7 J	µg/kg	FSM-SB-4	2 / 24	1.7 - 3.4	2.7	NA	890 c	34	SSL[4]	No	BSL
	85-01-8	Phenanthrene	5.1 J	81 J	µg/kg	FSM-SB-3	7 / 24	85 - 85	81	NA	1700000 n[7]	NA	SSL[4]	No	BSL
	129-00-0	Pyrene	4.9 J	140	µg/kg	FSM-SB-3	10 / 24	85 - 85	140	NA	170000 n	2400000	SSL[4]	No	BSL
	Pesticides/Polychlorinated Biphenyls														
	72-55-9	4,4'-DDE	0.26	5.7 J	µg/kg	FSM-SB-3	2 / 24	0.17 - 0.17	5.7	NA	1400 c	920	SSL[4]	No	BSL
	50-29-3	4,4'-DDT	0.13 J	9.1	µg/kg	FSM-SB-3	3 / 24	0.17 - 0.17	9.1	NA	1700 c	1340	SSL[4]	No	BSL
	309-00-2	Aldrin	0.16 J	0.84	µg/kg	FSM-SB-2	2 / 24	0.085 - 0.085	0.84	NA	29 c	13	SSL[4]	No	BSL
	5103-71-9	Alpha-Chlordane	0.19 NJ	0.19 NJ	µg/kg	FSM-SB-6	1 / 24	0.085 - 0.085	0.19	NA	1600 c[8]	260	SSL[4]	No	IFD
	60-57-1	Dieldrin	0.2	3.2	µg/kg	FSM-SB-2	3 / 24	0.17 - 0.17	3.2	NA	30 c	3.4	SSL[4]	No	BSL
	1031-07-8	Endosulfan Sulfate	0.44 NJ	0.44 NJ	µg/kg	FSM-SB-6	1 / 24	0.17 - 0.17	0.44	NA	37000 n[9]	60000	SSL[4]	No	IFD
	5103-74-2	Gamma-Chlordane	0.38	0.52	µg/kg	FSM-SB-2	2 / 24	0.085 - 0.085	0.52	NA	1600 c[8]	260	SSL[4]	No	BSL
	Inorganics														
	7429-90-5	**Aluminum**	**5140**	**28500**	**mg/kg**	**FSM-SB-2**	**24 / 24**	**20 - 20**	**28500**	**NA**	**7700 n**	**1100000**	**SSL[4]**	**Yes**	**ASL**
	7440-36-0	Antimony	0.016 J	0.14 J	mg/kg	FSM-SB-2	5 / 24	1 - 1	0.14	NA	3.1 n	13.2	SSL[4]	No	BSL
	7440-38-2	**Arsenic**	**0.29 J**	**4.6**	**mg/kg**	**FSM-SB-3**	**14 / 24**	**1 - 1**	**4.6**	**NA**	**0.39 c**	**0.026**	**SSL[4]**	**Yes**	**ASL**
	7440-39-3	Barium	53.5	213	mg/kg	FSM-SB-2	24 / 24	20 - 20	213	NA	1500 n	6000	SSL[4]	No	BSL
	7440-43-9	Cadmium	0.13 J	2.5	mg/kg	FSM-SB-4	14 / 24	0.5 - 0.5	2.5	NA	7 n	28	SSL[4]	No	BSL
	7440-70-2	Calcium	2660	141000	mg/kg	FSM-SB-2	24 / 24	500 - 500	141000	NA	NA	NA	SSL[4]	No	NUT
	7440-47-3	**Chromium**	**3**	**20.8**	**mg/kg**	**FSM-SB-2**	**24 / 24**	**1 - 1**	**20.8**	**NA**	**0.29 c[10]**	**3600000**	**SSL[4]**	**Yes**	**ASL**
	7440-48-4	**Cobalt**	**3 J**	**14.7**	**mg/kg**	**FSM-SB-2**	**24 / 24**	**5 - 5**	**14.7**	**NA**	**2.3 n**	**9.8**	**SSL[4]**	**Yes**	**ASL**
	7440-50-8	Copper	22.2	105	mg/kg	FSM-SB-4	24 / 24	2.5 - 2.5	105	NA	310 n	1020	SSL[4]	No	BSL
	57-12-5	Cyanide	0.071 J	1.3 J	mg/kg	FSM-SB-2	19 / 24	0.5 - 0.5	1.3	NA	160 n	148	SSL[4]	No	BSL
	7439-89-6	**Iron**	**6780**	**41800**	**mg/kg**	**FSM-SB-4**	**24 / 24**	**10 - 10**	**41800**	**NA**	**5500 n**	**12800**	**SSL[4]**	**Yes**	**ASL**

TABLE B-2.2a

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface/Subsurface Soil - Former Sugar Mill

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface/ Subsurface Soil	7439-92-1	Lead	0.86 J	710	mg/kg	FSM-SB-4	14 / 24	1 - 1	710	NA	800 n[11]	280	SSL[4]	No	BSL
	7439-95-4	Magnesium	1610	4810	mg/kg	FSM-SB-2	24 / 24	500 - 500	4810	NA	NA	NA	SSL[4]	No	NUT
	7439-96-5	**Manganese**	**191**	**650**	**mg/kg**	**FSM-SB-3**	**24 / 24**	**1.5 - 1.5**	**650**	**NA**	**180 n**	**1140**	**SSL[4]**	**Yes**	**ASL**
	7439-97-6	Mercury	0.022 J	0.67 J	mg/kg	FSM-SB-4	24 / 24	0.1 - 0.1	0.67	NA	2.3 n[12]	NA	SSL[4]	No	BSL
	7440-02-0	Nickel	1.4 J	19.2	mg/kg	FSM-SB-4	24 / 24	4 - 4	19.2	NA	150 n[13]	960	SSL[4]	No	BSL
	7440-09-7	Potassium	204 J	1920	mg/kg	FSM-SB-1	24 / 24	500 - 500	1920	NA	NA	NA	SSL[4]	No	NUT
	7782-49-2	Selenium	1.7 J	1.7 J	mg/kg	FSM-SB-2	1 / 24	3.5 - 3.5	1.7	NA	39 n	19	SSL[4]	No	IFD
	7440-22-4	Silver	0.92 J	3.5	mg/kg	FSM-SB-4	14 / 24	1 - 1	3.5	NA	39 n	32	SSL[4]	No	BSL
	7440-23-5	Sodium	106 J	527 J	mg/kg	FSM-SB-2	24 / 24	500 - 500	527	NA	NA	NA	SSL[4]	No	NUT
	7440-28-0	**Thallium**	**0.0066 J**	**0.8 J**	**mg/kg**	**FSM-SB-3**	**23 / 24**	**0.5 - 0.5**	**0.8**	**NA**	**0.078 n**	**0.52**	**SSL[4]**	**Yes**	**ASL**
	7440-62-2	**Vanadium**	**24.3**	**192**	**mg/kg**	**FSM-SB-2**	**24 / 24**	**5 - 5**	**192**	**NA**	**39 n[14]**	**3600**	**SSL[4]**	**Yes**	**ASL**
	7440-66-6	Zinc	31.3	742	mg/kg	FSM-SB-4	24 / 24	6 - 6	742	NA	2300 n	13600	SSL[4]	No	BSL

[1] Maximum detected concentration used for screening

[2] Screened against Regional Screening Levels, November 2011, for residential soil, adjusted to a cancer risk of $1\times1(^{6}$ and hazard quotient of 0.1. http://www.epa.gov/region09/waste/sfund/prg/index.html

[3] Rationale Codes:

Selection Reason: ASL = above screening level

Deletion Reason: BSL = below screening level

IFD = detection frequency less than 5%

NUT = essential nutrient

NTX = no toxicity information available

[4] Potential ARAR/TBC value from Regional Screening Levels, June 2011, for protection of groundwater soil screening levels, based on a dilution factor of 20.

[5] screening value for acenaphthene

[6] screening value for pyrene

[7] screening value for anthracene

[8] screening value for chlordane

[9] screening value for endosulfan

[10] screening value for chromium VI

[11] OSWER screening value for industrial soil

[12] screening value for mercuric chloride (and other mercury salts)

[13] screening value for nickel soluble salts

[14] screening value for vanadium and compounds

NA = not available

ND = not detected

n = screening toxicity value based on noncancer effects

c = screening toxicity value based on cancer effects

SSL = soil screening level

COPC = chemical of potential concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J = qualifier for estimated value

NJ = qualifier for tentatively identified and estimated value

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

4,4'-DDE = p,p'-dichlorodiphenyldichloroethylene

4,4'-DDT = p,p'-dichlorodiphenyltrichloroethane

TABLE B-2.2b

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface/Subsurface Soil - Puerto Rico Beverage

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface/ Subsurface Soil	**Volatile Organic Compounds**														
	78-93-3	2-Butanone	4.2 J	21	µg/kg	PRB-SB-5	5 / 20	10 - 10	21	NA	2800000 n	30000	SSL[4]	No	BSL
	67-64-1	Acetone	14	100	µg/kg	PRB-SB-3	11 / 20	10 - 10	100	NA	6100000 n	90000	SSL[4]	No	BSL
	Semi-volatile Organic Compounds														
	99-09-2	3-Nitroaniline	54 J	54 J	µg/kg	PRB-SB-1	1 / 20	170 - 170	54	NA	NA	NA	SSL[4]	No	NTX
	56-55-3	Benzo(a)anthracene	3.9 J	3.9 J	µg/kg	PRB-SB-6	1 / 20	85 - 85	3.9	NA	150 c	NA	SSL[4]	No	BSL
	50-32-8	Benzo(a)pyrene	4.4 J	4.4 J	µg/kg	PRB-SB-6	1 / 20	85 - 85	4.4	NA	15 c	4800	SSL[4]	No	BSL
	205-99-2	Benzo(b)fluoranthene	4.4 J	4.4 J	µg/kg	PRB-SB-6	1 / 20	85 - 85	4.4	NA	150 c	NA	SSL[4]	No	BSL
	191-24-2	Benzo(g,h,i)perylene	4 J	4 J	µg/kg	PRB-SB-6	1 / 20	85 - 85	4	NA	170000 n[5]	NA	SSL[4]	No	BSL
	117-81-7	Bis(2-Ethylhexyl)Phthalate	1100	1100	µg/kg	PRB-SB-5	1 / 20	85 - 85	1100	NA	35000 c	22000	SSL[4]	No	BSL
	85-68-7	Butylbenzylphthalate	39 J	200	µg/kg	PRB-SB-5	3 / 20	85 - 85	200	NA	260000 c	10200	SSL[4]	No	BSL
	218-01-9	Chrysene	4.6 J	6.4 J	µg/kg	PRB-SB-5	2 / 20	85 - 85	6.4	NA	15000 c	NA	SSL[4]	No	BSL
	206-44-0	Fluoranthene	4.8 J	4.8 J	µg/kg	PRB-SB-6	1 / 20	85 - 85	4.8	NA	230000 n	3200000	SSL[4]	No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	4 J	4 J	µg/kg	PRB-SB-6	1 / 20	85 - 85	4	NA	150 c	NA	SSL[4]	No	BSL
	129-00-0	Pyrene	5.5 J	5.5 J	µg/kg	PRB-SB-6	1 / 20	85 - 85	5.5	NA	170000 n	2400000	SSL[4]	No	BSL
	Pesticides/Polychlorinated Biphenyls														
	72-55-9	4,4'-DDE	0.31	1.3 NJ	µg/kg	PRB-SB-5	2 / 20	0.17 - 0.17	1.3	NA	1400 c	920	SSL[4]	No	BSL
	50-29-3	4,4'-DDT	0.98 J	0.98 J	µg/kg	PRB-SB-5	1 / 20	0.17 - 0.17	0.98	NA	1700 c	1340	SSL[4]	No	BSL
	5103-71-9	Alpha-Chlordane	0.24 J	4 NJ	µg/kg	PRB-SB-5	2 / 20	0.085 - 0.085	4	NA	1600 c[6]	260	SSL[4]	No	BSL
	5103-74-2	Gamma-Chlordane	0.14 J	5.6	µg/kg	PRB-SB-5	3 / 20	0.085 - 0.085	5.6	NA	1600 c[6]	260	SSL[4]	No	BSL
	76-44-8	Heptachlor	1.2 NJ	1.2 NJ	µg/kg	PRB-SB-5	1 / 20	0.085 - 0.085	1.2	NA	110 c	24	SSL[4]	No	BSL
	1024-57-3	Heptachlor Epoxide	0.12 J	1.5 J	µg/kg	PRB-SB-5	3 / 20	0.085 - 0.085	1.5	NA	53 c	3	SSL[4]	No	BSL
	Inorganics														
	7429-90-5	**Aluminum**	**7060**	**37800**	**mg/kg**	**PRB-SB-1**	**20 / 20**	**20 - 20**	**37800**	**NA**	**7700 n**	**1100000**	**SSL[4]**	**Yes**	**ASL**
	7440-36-0	Antimony	0.0034 J	0.013 J	mg/kg	PRB-SB-6	9 / 20	1 - 1	0.013	NA	3.1 n	13.2	SSL[4]	No	BSL
	7440-38-2	**Arsenic**	**0.27 J**	**2.9**	**mg/kg**	**PRB-SB-5**	**4 / 20**	**1 - 1**	**2.9**	**NA**	**0.39 c**	**0.026**	**SSL[4]**	**Yes**	**ASL**
	7440-39-3	Barium	57.5	268	mg/kg	PRB-SB-1	20 / 20	20 - 20	268	NA	1500 n	6000	SSL[4]	No	BSL
	7440-43-9	Cadmium	0.1 J	1.1	mg/kg	PRB-SB-5	4 / 20	0.5 - 0.5	1.1	NA	7 n	28	SSL[4]	No	BSL
	7440-70-2	Calcium	868	5150	mg/kg	PRB-SB-1	20 / 20	500 - 500	5150	NA	NA	NA	SSL[4]	No	NUT
	7440-47-3	**Chromium**	**0.9 J**	**27.5**	**mg/kg**	**PRB-SB-5**	**20 / 20**	**1 - 1**	**27.5**	**NA**	**0.29 c[7]**	**3600000**	**SSL[4]**	**Yes**	**ASL**
	7440-48-4	**Cobalt**	**2.1 J**	**16.1**	**mg/kg**	**PRB-SB-1**	**20 / 20**	**5 - 5**	**16.1**	**NA**	**2.3 n**	**9.8**	**SSL[4]**	**Yes**	**ASL**
	7440-50-8	Copper	27.3	140	mg/kg	PRB-SB-1	20 / 20	2.5 - 2.5	140	NA	310 n	1020	SSL[4]	No	BSL
	57-12-5	Cyanide	0.039 J	0.88	mg/kg	PRB-SB-6	13 / 20	0.5 - 0.5	0.88	NA	160 n	148	SSL[4]	No	BSL
	7439-89-6	**Iron**	**13200**	**44700**	**mg/kg**	**PRB-SB-1**	**20 / 20**	**10 - 10**	**44700**	**NA**	**5500 n**	**12800**	**SSL[4]**	**Yes**	**ASL**
	7439-92-1	Lead	0.68 J	83.3	mg/kg	PRB-SB-5	7 / 20	1 - 1	83.3	NA	800 n[8]	280	SSL[4]	No	BSL
	7439-95-4	Magnesium	1120	5490	mg/kg	PRB-SB-1	20 / 20	500 - 500	5490	NA	NA	NA	SSL[4]	No	NUT
	7439-96-5	**Manganese**	**89.6**	**474**	**mg/kg**	**PRB-SB-1**	**20 / 20**	**1.5 - 1.5**	**474**	**NA**	**180 n**	**1140**	**SSL[4]**	**Yes**	**ASL**
	7439-97-6	Mercury	0.023 J	0.9	mg/kg	PRB-SB-5	20 / 20	0.1 - 0.1	0.9	NA	2.3 n[9]	NA	SSL[4]	No	BSL
	7440-02-0	Nickel	0.32 J	6	mg/kg	PRB-SB-5	20 / 20	4 - 4	6	NA	150 n[10]	960	SSL[4]	No	BSL
	7440-09-7	Potassium	333 J	1420	mg/kg	PRB-SB-5	20 / 20	500 - 500	1420	NA	NA	NA	SSL[4]	No	NUT
	7440-23-5	Sodium	95.3 J	399 J	mg/kg	PRB-SB-2	20 / 20	500 - 500	399	NA	NA	NA	SSL[4]	No	NUT

TABLE B-2.2b

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface/Subsurface Soil - Puerto Rico Beverage

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface/ Subsurface Soil	7440-28-0	Thallium	0.014 J	0.069 J	mg/kg	PRB-SB-1	20 / 20	0.5 - 0.5	0.069	NA	0.078 n	0.52	SSL[4]	No	BSL
	7440-62-2	**Vanadium**	**31.9**	**162**	**mg/kg**	**PRB-SB-1**	**20 / 20**	**5 - 5**	**162**	**NA**	**39 n[11]**	**3600**	**SSL[4]**	**Yes**	**ASL**
	7440-66-6	Zinc	11.3	438	mg/kg	PRB-SB-5	20 / 20	6 - 6	438	NA	2300 n	13600	SSL[4]	No	BSL

[1] Maximum detected concentration used for screening

[2] Screened against Regional Screening Levels, November 2011, for residential soil, adjusted to a cancer risk of 1×10^{-6} and hazard quotient of 0.1. http://www.epa.gov/region09/waste/sfund/prg/index.html

[3] Rationale Codes:

Selection Reason: ASL = above screening level

Deletion Reason: BSL = below screening level

NUT = essential nutrient

NTX = no toxicity information available

NA = not available

ND = not detected

n = screening toxicity value based on noncancer effects

c = screening toxicity value based on cancer effects

SSL = soil screening level

COPC = chemical of potential concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J = qualifier for estimated value

NJ = qualifier for tentatively identified and estimated value

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

4,4'-DDE = p,p'-dichlorodiphenyldichloroethylene

4,4'-DDT = p,p'-dichlorodiphenyltrichloroethane

[4] Potential ARAR/TBC value from Regional Screening Levels, June 2011, for protection of groundwater soil screening levels, based on a dilution factor of 20.

[5] screening value for pyrene

[6] screening value for chlordane

[7] screening value for chromium VI

[8] OSWER screening value for industrial soil

[9] screening value for mercuric chloride (and other mercury salts)

[10] screening value for nickel soluble salts

[11] screening value for vanadium and compounds

TABLE B-2.3

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Groundwater	**Volatile Organic Compounds**														
	76-13-1	1,1,2-Trichloro-1,2,2-	3.2	23	µg/L	MW-AD	5 / 35	0.5 - 0.5	23	NA	5300 n	NL	PRWQS	No	BSL
	75-34-3	1,1-Dichloroethane	0.27 J	0.75	µg/L	MW-I	6 / 35	0.5 - 0.5	0.75	NA	2.4 c	NL	PRWQS	No	BSL
	75-35-4	1,1-Dichloroethene	0.22 J	25 J	µg/L	MW-L	12 / 35	0.5 - 0.5	25	NA	26 n	7	PRWQS	No	BSL
	107-06-2	1,2-Dichloroethane	0.2	0.2	µg/L	MW-AD	1 / 35	0.2 - 0.2	0.2	NA	0.15 c	3.8	PRWQS	No	IFD
	78-87-5	1,2-Dichloropropane	0.52	0.52	µg/L	MW-N	1 / 35	0.2 - 0.2	0.52	NA	0.38 c	5	PRWQS	No	IFD
	67-64-1	Acetone	1.6 J	15	µg/L	MW-N	2 / 35	5 - 5	15	NA	1200 n	NL	PRWQS	No	BSL
	75-25-2	Bromoform	1.6	5	µg/L	MW-M	3 / 35	0.5 - 0.5	5	NA	7.9 c	43	PRWQS	No	BSL
	75-15-0	Carbon Disulfide	1.4	1.4	µg/L	MW-AS	1 / 35	0.5 - 0.5	1.4	NA	72 n	NL	PRWQS	No	IFD
	75-00-3	Chloroethane	0.27 J	0.27 J	µg/L	MW-I	1 / 35	0.5 - 0.5	0.27	NA	2100 n	NL	PRWQS	No	IFD
	156-59-2	**cis-1,2-Dichloroethene**	**0.38 J**	**300**	**µg/L**	**MW-B**	**16 / 35**	**0.5 - 0.5**	**300**	**NA**	**2.8 n**	**70**	**DWR**	**Yes**	**ASL**
	124-48-1	Dibromochloromethane	0.54	0.54	µg/L	MW-M	1 / 35	0.5 - 0.5	0.54	NA	0.15 c	4	PRWQS	No	IFD
	1634-04-4	Methyl Tert-Butyl Ether	0.27 J	2	µg/L	MW-K	8 / 35	0.5 - 0.5	2	NA	12 c	NL	PRWQS	No	BSL
	75-09-2	Methylene Chloride	1.3	1.7	µg/L	MW-FD	4 / 35	0.5 - 0.5	1.7	NA	4.7 c	46	PRWQS	No	BSL
	127-18-4	**Tetrachloroethene**	**0.1 J**	**8.5 J**	**µg/L**	**MW-FD**	**9 / 35**	**0.2 - 0.2**	**8.5**	**NA**	**0.072 c**	**5**	**PRWQS**	**Yes**	**ASL**
	156-60-5	**trans-1,2-Dichloroethene**	**0.99**	**13**	**µg/L**	**MW-B**	**4 / 35**	**0.5 - 0.5**	**13**	**NA**	**8.6 n**	**100**	**PRWQS**	**Yes**	**ASL**
	10061-02-6	trans-1,3-Dichloropropene	0.2 J	0.2 J	µg/L	MW-N	1 / 35	0.2 - 0.2	0.2	NA	0.41 c[4]	3.4	PRWQS	No	IFD
	79-01-6	**Trichloroethene**	**0.29 J**	**1.9**	**µg/L**	**MW-FD**	**7 / 35**	**0.5 - 0.5**	**1.9**	**NA**	**0.26 n**	**5**	**PRWQS**	**Yes**	**ASL**
	75-69-4	Trichlorofluoromethane	0.36 J	8	µg/L	MW-L	6 / 35	0.5 - 0.5	8	NA	110 n	NL	PRWQS	No	BSL
	75-01-4	**Vinyl Chloride**	**0.22**	**0.73**	**µg/L**	**MW-B**	**3 / 35**	**0.2 - 0.2**	**0.73**	**NA**	**0.015 c**	**0.25**	**PRWQS**	**Yes**	**TOX**
	Semi-volatile Organic Compounds														
	117-81-7	Bis(2-Ethylhexyl)Phthalate	56	56	µg/L	MW-AD	1 / 34	2.5 - 2.5	56	NA	0.071 c	12	PRWQS	No	IFD
	85-68-7	Butylbenzylphthalate	0.52 J	0.52 J	µg/L	MW-FS	1 / 34	2.5 - 2.5	0.52	NA	14 c	1500	PRWQS	No	IFD
	621-64-7	N-Nitroso-Di-N-Propylamine	0.096	0.096	µg/L	MW-C	1 / 34	0.05 - 0.05	0.096	NA	0.0093 c	0.05	PRWQS	No	IFD
	87-86-5	Pentachlorophenol	0.049 J	0.1 J	µg/L	MAUNABO-1	2 / 34	0.1 - 0.1	0.1	NA	0.17 c	1	PRWQS	No	BSL
	108-95-2	Phenol	0.93 J	0.93 J	µg/L	MW-AS	1 / 34	2.5 - 2.5	0.93	NA	450 n	21000	PRWQS	No	IFD
	Pesticides/Polychlorinated Biphenyls														
	72-54-8	4,4'-DDD	0.019 NJ	0.019 NJ	µg/L	MW-I	1 / 34	0.0025 - 0.005	0.019	NA	0.28 c	0.0022	PRWQS	No	IFD
	319-85-7	Beta-BHC	0.002 J	0.002 J	µg/L	MW-K	1 / 34	0.0013 - 0.0025	0.002	NA	0.022 c	0.091	PRWQS	No	IFD
	319-86-8	Delta-BHC	0.0038 J	0.0038 J	µg/L	MW-I	1 / 34	0.0013 - 0.0025	0.0038	NA	0.022 c[5]	NL	PRWQS	No	IFD
	959-98-8	Endosulfan I	0.027	0.051	µg/L	MW-K	2 / 34	0.0013 - 0.0025	0.051	NA	7.8 n[6]	62	PRWQS	No	BSL
	Inorganics														
	7429-90-5	**Aluminum**	**48.2**	**8190 J**	**µg/L**	**MW-C**	**22 / 31**	**20 - 20**	**8190**	**NA**	**1600 n**	**NL**	**PRWQS**	**Yes**	**ASL**
	7440-38-2	**Arsenic**	**0.41 J**	**7.2**	**µg/L**	**MW-J**	**16 / 31**	**1 - 1**	**7.2**	**NA**	**0.045 c**	**10**	**PRWQS**	**Yes**	**ASL**
	7440-39-3	**Barium**	**27.8**	**346 J**	**µg/L**	**MW-K**	**31 / 31**	**10 - 10**	**346**	**NA**	**290 n**	**2000**	**DWR**	**Yes**	**ASL**
	7440-41-7	Beryllium	0.13 J	0.13 J	µg/L	MW-C	1 / 31	1 - 1	0.13	NA	1.6 n	4	DWR	No	IFD
	7440-70-2	Calcium	24800	105000	µg/L	MAUNABO-1	31 / 31	500 - 500	105000	NA	NA	NL	PRWQS	No	NUT
	7440-47-3	**Chromium**	**2.2**	**33.4**	**µg/L**	**MW-C**	**6 / 31**	**2 - 2**	**33.4**	**NA**	**0.031 c[7]**	**100**	**PRWQS**	**Yes**	**ASL**
	7440-48-4	**Cobalt**	**0.12 J**	**6.5**	**µg/L**	**MW-C**	**13 / 31**	**1 - 1**	**6.5**	**NA**	**0.47 n**	**NL**	**PRWQS**	**Yes**	**ASL**
	7440-50-8	**Copper**	**0.45 J**	**211**	**µg/L**	**MAUNABO-1**	**23 / 31**	**2 - 2**	**211**	**NA**	**62 n**	**1300**	**PRWQS**	**Yes**	**ASL**
	57-12-5	Cyanide	2.4 J	11.2	µg/L	MW-AD	8 / 31	10 - 10	11.2	NA	31 n	200	PRWQS	No	BSL
	7439-89-6	**Iron**	**28 J**	**16600**	**µg/L**	**MW-C**	**28 / 31**	**200 - 200**	**16600**	**NA**	**1100 n**	**NL**	**PRWQS**	**Yes**	**ASL**
	7439-92-1	Lead	0.08 J	1.5	µg/L	MW-C	15 / 31	1 - 1	1.5	NA	15 [8]	15	PRWQS	No	BSL
	7439-95-4	Magnesium	11600	46300	µg/L	MAUNABO-1	31 / 31	500 - 500	46300	NA	NA	NL	PRWQS	No	NUT
	7439-96-5	**Manganese**	**0.62 J**	**2340 J**	**µg/L**	**MW-K**	**31 / 31**	**1 - 1**	**2340**	**NA**	**32 n**	**NL**	**PRWQS**	**Yes**	**ASL**

TABLE B-2.3

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Groundwater	7439-97-6	Mercury	0.054 J	0.054 J	µg/L	MAUNABO-1	1 / 31	0.2 - 0.2	0.054	NA	0.43 n[9]	0.05	PRWQS	No	IFD
	7440-02-0	Nickel	0.19 J	18.4	µg/L	MW-C	13 / 31	1 - 1	18.4	NA	30 n[10]	610	PRWQS	No	BSL
	7440-09-7	Potassium	714	19700	µg/L	MW-FD	31 / 31	500 - 500	19700	NA	NA	NL	PRWQS	No	NUT
	7782-49-2	Selenium	1.5 J	1.5 J	µg/L	MAUNABO-4	1 / 31	5 - 5	1.5	NA	7.8 n	50	PRWQS	No	IFD
	7440-23-5	Sodium	33500	97200	µg/L	MW-AS	31 / 31	500 - 500	97200	NA	NA	NL	PRWQS	No	NUT
	7440-28-0	Thallium	1.6 J	1.6 J	µg/L	MAUNABO-4	1 / 31	1 - 1	1.6	NA	0.016 n	0.24	PRWQS	No	IFD
	7440-62-2	**Vanadium**	**0.72 J**	**68.2**	**µg/L**	**MW-C**	**26 / 31**	**5 - 5**	**68.2**	**NA**	**7.8 n[11]**	**NL**	**PRWQS**	**Yes**	**ASL**
	7440-66-6	Zinc	1.8 J	34.3 J	µg/L	MW-C	27 / 31	2 - 2	34.3	NA	470 n	NL	PRWQS	No	BSL

[1] Maximum detected concentration used for screening

[2] Screened against Regional Screening Levels, November 2011, for tap water, adjusted to a cancer risk of 1×10^{-6} and hazard quotient of 0.1. http://www.epa.gov/region09/waste/sfund/prg/index.html

[3] Rationale Codes:

Selection Reason: ASL = above screening level

Deletion Reason: BSL = below screening level
IFD = detection frequency less than 5%
NUT = essential nutrient

[4] screening value for 1,3-dichloropropene

[5] screening value for hexachlorocyclohexane

[6] screening value for endosulfan

[7] screening value for chromium VI

[8] Puerto Rico Water Quality Standard

[9] screening value for mercuric chloride (and other mercury salts)

[10] screening value for nickel soluble salts

[11] screening value for vanadium and compounds

NA = not available
ND = not detected
n = screening toxicity value based on noncancer effects
c = screening toxicity value based on cancer effects
PRWQS = Puerto Rico Water Quality Standard
DWR = National Primary Drinking Water Regulation
COPC = chemical of potential concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = qualifier for estimated value
NJ = qualifier for tentatively identified and estimated value
µg/L = micrograms per liter
4,4'-DDD = p,p'-dichlorodiphenyldichloroethane
BHC = benzene hexachloride

TABLE B-2.4

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Surface Water	**Volatile Organic Compounds**														
	75-27-4	**Bromodichloromethane**	**0.38 J**	**1**	**µg/L**	**SW-06**	**3 / 6**	**0.5 - 0.5**	**1**	**NA**	**0.12 c**	**5.5**	**PRWQS**	**Yes**	**ASL**
	75-25-2	Bromoform	0.43 J	0.64	µg/L	SW-06	2 / 6	0.5 - 0.5	0.64	NA	8.5 c	43	PRWQS	No	BSL
	124-48-1	**Dibromochloromethane**	**0.57**	**1.3**	**µg/L**	**SW-06**	**3 / 6**	**0.5 - 0.5**	**1.3**	**NA**	**0.15 c**	**4**	**PRWQS**	**Yes**	**ASL**
	Semi-volatile Organic Compounds														
	117-81-7	Bis(2-Ethylhexyl)Phthalate	1.1 J	2.5	µg/L	SW-07	3 / 6	2.5 - 2.5	2.5	NA	4.8 c	12	PRWQS	No	BSL
	Inorganics														
	7429-90-5	Aluminum	27.4	41.3	µg/L	SW-07	3 / 6	20 - 20	41.3	NA	3700 n	NL	PRWQS	No	BSL
	7440-39-3	Barium	34.4	50.5	µg/L	SW-05	6 / 6	10 - 10	50.5	NA	730 n	NL	PRWQS	No	BSL
	7440-70-2	Calcium	15800	24500	µg/L	SW-05	6 / 6	500 - 500	24500	NA	NA	NL	PRWQS	No	NUT
	7440-50-8	Copper	2.1	3.3	µg/L	SW-03	4 / 6	2 - 2	3.3	NA	150 n	12	PRWQS	No	BSL
	57-12-5	Cyanide	4.3 J	4.3 J	µg/L	SW-03	1 / 6	10 - 10	4.3	NA	73 n	5.2	PRWQS	No	BSL
	7439-95-4	Magnesium	7850	9650	µg/L	SW-05	5 / 6	500 - 500	9650	NA	NA	NL	PRWQS	No	NUT
	7439-96-5	Manganese	1.8	44.8	µg/L	SW-04	6 / 6	1 - 1	44.8	NA	88 n	NL	PRWQS	No	BSL
	7440-09-7	Potassium	1240	2300	µg/L	SW-05	6 / 6	500 - 500	2300	NA	NA	NL	PRWQS	No	NUT
	7440-23-5	Sodium	21300	1910000	µg/L	SW-03	6 / 6	500 - 500	1910000	NA	NA	NL	PRWQS	No	NUT
	7440-66-6	Zinc	0.52 J	3.8	µg/L	SW-06	6 / 6	2 - 2	3.8	NA	1100 n	105	PRWQS	No	BSL

[1] Maximum detected concentration used for screening

[2] Screened against Regional Screening Levels, November 2011, for tap water, adjusted to a cancer risk of 1×10^{-6} and hazard quotient of 0.1. http://www.epa.gov/region09/waste/sfund/prg/index.html

[3] Rationale Codes:

Selection Reason: ASL = above screening level

Deletion Reason: BSL = below screening level

NUT = essential nutrient

NA = not available

ND = not detected

n = screening toxicity value based on noncancer effects

c = screening toxicity value based on cancer effects

PRWQS = Puerto Rico Water Quality Standard

COPC = chemical of potential concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered

J = qualifier for estimated value

µg/L = micrograms per liter

TABLE B-2.5

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Background Value	Screening Toxicity Value (n/c) [2]	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Yes/No)	Rationale for Selection or Deletion [3]
Sediment	**Semi-volatile Organic Compounds**														
	117-81-7	Bis(2-Ethylhexyl)Phthalate	81 J	81 J	µg/kg	SD-05	1 / 6	85 - 85	81	NA	35000 c	NA	NA	No	BSL
	Pesticides/Polychlorinated Biphenyls														
	72-54-8	4,4'-DDD	0.31 J	0.31 J	µg/kg	SD-05	1 / 6	0.17 - 0.17	0.31	NA	2000 c	NA	NA	No	BSL
	72-55-9	4,4'-DDE	0.3 J	0.3 J	µg/kg	SD-05	1 / 6	0.17 - 0.17	0.3	NA	1400 c	NA	NA	No	BSL
	50-29-3	4,4'-DDT	0.55 J	0.55 J	µg/kg	SD-05	1 / 6	0.17 - 0.17	0.55	NA	1700 c	NA	NA	No	BSL
	11097-69-1	Aroclor 1254	9.2 J	9.2 J	µg/kg	SD-07	1 / 6	33 - 33	9.2	NA	110 n	NA	NA	No	BSL
	319-85-7	Beta-BHC	0.014 J	0.014 J	µg/kg	SD-03	1 / 6	0.085 - 0.085	0.014	NA	270 c	NA	NA	No	BSL
	72-43-5	Methoxychlor	0.051 J	0.062 J	µg/kg	SD-03	2 / 6	0.85 - 0.85	0.062	NA	31000 n	NA	NA	No	BSL
	Inorganics														
	7429-90-5	Aluminum	2580 J	5350 J	mg/kg	SD-05	6 / 6	20 - 20	5350	NA	7700 n	NA	NA	No	BSL
	7440-38-2	**Arsenic**	**0.65**	**2.7**	**mg/kg**	**SD-04**	**2 / 6**	**0.5 - 0.5**	**2.7**	**NA**	**0.39 c**	**NA**	**NA**	**Yes**	**ASL**
	7440-39-3	Barium	27	71.9	mg/kg	SD-05	6 / 6	5 - 5	71.9	NA	1500 n	NA	NA	No	BSL
	7440-70-2	Calcium	1040	1670	mg/kg	SD-05	6 / 6	500 - 500	1670	NA	NA	NA	NA	No	NUT
	7440-47-3	**Chromium**	**2.1 J**	**6 J**	**mg/kg**	**SD-05**	**6 / 6**	**1 - 1**	**6**	**NA**	**0.29 c [4]**	**NA**	**NA**	**Yes**	**ASL**
	7440-48-4	**Cobalt**	**2.5**	**7.1**	**mg/kg**	**SD-05**	**6 / 6**	**0.5 - 0.5**	**7.1**	**NA**	**2.3 n**	**NA**	**NA**	**Yes**	**ASL**
	7440-50-8	Copper	10.6	31.8	mg/kg	SD-05	6 / 6	1 - 1	31.8	NA	310 n	NA	NA	No	BSL
	7439-89-6	**Iron**	**5220 J**	**13500 J**	**mg/kg**	**SD-05**	**6 / 6**	**10 - 10**	**13500**	**NA**	**5500 n**	**NA**	**NA**	**Yes**	**ASL**
	7439-92-1	Lead	0.6 J	2.1 J	mg/kg	SD-05	5 / 6	0.5 - 0.5	2.1	NA	800 n [5]	NA	NA	No	BSL
	7439-95-4	Magnesium	794	1890	mg/kg	SD-05	6 / 6	500 - 500	1890	NA	NA	NA	NA	No	NUT
	7439-96-5	**Manganese**	**237**	**333**	**mg/kg**	**SD-02**	**6 / 6**	**0.5 - 0.5**	**333**	**NA**	**180 n**	**NA**	**NA**	**Yes**	**ASL**
	7440-02-0	Nickel	0.63	2.9	mg/kg	SD-04	6 / 6	0.5 - 0.5	2.9	NA	150 n [6]	NA	NA	No	BSL
	7440-09-7	Potassium	273 J	790	mg/kg	SD-03	6 / 6	500 - 500	790	NA	NA	NA	NA	No	NUT
	7440-62-2	**Vanadium**	**33.5 J**	**70.6 J**	**mg/kg**	**SD-05**	**6 / 6**	**2.5 - 2.5**	**70.6**	**NA**	**39 n [7]**	**NA**	**NA**	**Yes**	**ASL**
	7440-66-6	Zinc	11.9	36.1	mg/kg	SD-04	6 / 6	1 - 1	36.1	NA	2300 n	NA	NA	No	BSL

[1] Maximum detected concentration used for screening

[2] Screened against Regional Screening Levels, November 2011, for residential soil, adjusted to a cancer risk of 1×10^{-6} and hazard quotient of 0.1. http://www.epa.gov/region09/waste/sfund/prg/index.html

[3] Rationale Codes:

Selection Reason: ASL = above screening level
ASL2 = above ARAR/TBC level
TOX = group A carcinogen

Deletion Reason: BSL = below screening level
BSL2 = below ARAR/TBC level
IFD = detection frequency less than 5%
NUT = essential nutrient
NTX = no toxicity information available

[4] screening value for chromium VI

[5] OSWER screening value for industrial soil

[6] screening value for nickel soluble salts

[7] screening value for vanadium and compounds

NA = not available
ND = not detected
n = screening toxicity value based on noncancer effects
c = screening toxicity value based on cancer effects

COPC = chemical of potential concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = qualifier for estimated value
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

TABLE B-3.1a
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil - Former Sugar Mill

Exposure Point	Chemical of Potential Concern	Unit	Mean Concentration (1)	Upper Confidence Limit (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration (2)			
						Value	Unit	Statistic	Rationale (3)
Surface Soil	**Semi-volatile Organic Compounds**								
	Benzo(a)pyrene	µg/kg	33	66	76 J	66	µg/kg	UCL-NP	95% KM (t) UCL
	Dibenzo(a,h)anthracene	µg/kg	15	NA	18 J	18	µg/kg	Max	<4 detected values
	Inorganics								
	Aluminum	mg/kg	10513	13777	15800	13777	mg/kg	UCL-N	95% Student's-t UCL
	Arsenic	mg/kg	2.6	3.6	4.6	3.6	mg/kg	UCL-N	95% Student's-t UCL
	Chromium	mg/kg	9.8	15.0	17.1	15.0	mg/kg	UCL-N	95% Student's-t UCL
	Cobalt	mg/kg	6.4	8.8	10.5	8.8	mg/kg	UCL-N	95% Student's-t UCL
	Iron	mg/kg	28117	37435	41800	37435	mg/kg	UCL-N	95% Student's-t UCL
	Manganese	mg/kg	387	489	547	489	mg/kg	UCL-N	95% Student's-t UCL
	Vanadium	mg/kg	48.8	63.7	69.3	63.7	mg/kg	UCL-N	95% Student's-t UCL

µg/kg = microgram per kilogram
mg/kg = milligram per kilogram
J = qualifier for estimated value

Notes:
(1) Mean and upper confidence limit (UCL) concentrations are calculated using ProUCL version 4.1.00 for chemicals with at least 5 samples in a dataset and 4 detected values.
(2) Exposure point concentration is lower of maximum concentration and UCL.
(3) Rationale: UCL-N = upper confidence limit of mean of normal distribution
UCL-NP = upper confidence limit of mean of non-parametric distribution
Max = maximum detected concentration

TABLE B-3.1b
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Surface Soil - Puerto Rico Beverage

Exposure Point	Chemical of Potential Concern	Unit	Mean Concentration [1]	Upper Confidence Limit [1]	Maximum Concentration (Qualifier)	Exposure Point Concentration [2]			
						Value	Unit	Statistic	Rationale [3]
Surface Soil	**Inorganics**								
	Aluminum	mg/kg	10240	13040	15700	13040	mg/kg	UCL-N	95% Student's-t UCL
	Arsenic	mg/kg	0.8	NA	2.9	2.9	mg/kg	Max	<4 detected values
	Chromium	mg/kg	7.0	25.1	27.5	25.1	mg/kg	UCL-NP	95% Chebyshev (Mean, Sd) UCL
	Cobalt	mg/kg	4.8	6.4	7.5	6.4	mg/kg	UCL-N	95% Student's-t UCL
	Iron	mg/kg	23467	29438	35900	29438	mg/kg	UCL-N	95% Student's-t UCL
	Manganese	mg/kg	269	349	365	349	mg/kg	UCL-N	95% Student's-t UCL
	Vanadium	mg/kg	44.0	56.6	71.8	56.6	mg/kg	UCL-N	95% Student's-t UCL

µg/kg = microgram per kilogram
mg/kg = milligram per kilogram
J = qualifier for estimated value
NA = not available

Notes:
[1] Mean and upper confidence limit (UCL) concentrations are calculated using ProUCL version 4.1.00 for chemicals with at least 5 samples in a dataset and 4 detected values.
[2] Exposure point concentration is lower of maximum concentration and UCL.
[3] Rationale: UCL-N = upper confidence limit of mean of normal distribution
UCL-NP = upper confidence limit of mean of non-parametric distribution
Max = maximum detected concentration

TABLE B-3.2a
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Medium:	Soil
Exposure Medium:	Surface/Subsurface Soil - Former Sugar Mill

Exposure Point	Chemical of Potential Concern	Unit	Mean Concentration (1)	Upper Confidence Limit (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration (2)			
						Value	Unit	Statistic	Rationale (3)
Surface/ Subsurface Soil	**Semi-volatile Organic Compounds**								
	Benzo(a)pyrene	µg/kg	29	46	76 J	46	µg/kg	UCL-NP	95% KM (t) UCL
	Dibenzo(a,h)anthracene	µg/kg	13	NA	18 J	18	µg/kg	Max	<4 detected values
	Inorganics								
	Aluminum	mg/kg	15516	17264	28500	17264	mg/kg	UCL-N	95% Student's-t UCL
	Arsenic	mg/kg	1.5	1.9	4.6	1.9	mg/kg	UCL-N	95% Student's-t UCL
	Chromium	mg/kg	8.3	9.9	20.8	9.9	mg/kg	UCL-N	95% Modified-t UCL
	Cobalt	mg/kg	9.9	10.9	14.7	10.9	mg/kg	UCL-N	95% Student's-t UCL
	Iron	mg/kg	26099	29045	41800	29045	mg/kg	UCL-N	95% Student's-t UCL
	Manganese	mg/kg	386	435	650	435	mg/kg	UCL-N	95% Student's-t UCL
	Thallium	mg/kg	0.1	0.2	0.8 J	0.2	mg/kg	UCL-NP	95% KM (Chebyshev) UCL
	Vanadium	mg/kg	84	96	192	96	mg/kg	UCL-N	95% Student's-t UCL

µg/kg = microgram per kilogram
mg/kg = milligram per kilogram
J = qualifier for estimated value

Notes:
(1) Mean and upper confidence limit (UCL) concentrations are calculated using ProUCL version 4.1.00 for chemicals with at least 5 samples in a dataset and 4 detected values.
(2) Exposure point concentration is lower of maximum concentration and UCL.
(3) Rationale: UCL-N = upper confidence limit of mean of normal distribution
UCL-NP = upper confidence limit of mean of non-parametric distribution

TABLE B-3.2b
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Future
Medium:	Soil
Exposure Medium:	Surface/Subsurface Soil - Puerto Rico Beverage

Exposure Point	Chemical of Potential Concern	Unit	Mean Concentration (1)	Upper Confidence Limit (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration (2)			
						Value	Unit	Statistic	Rationale (3)
Surface/ Subsurface Soil	**Inorganics**								
	Aluminum	mg/kg	13551	16378	37800	16378	mg/kg	UCL-G	95% Approximate Gamma UCL
	Arsenic	mg/kg	0.5	0.7	2.9	0.7	mg/kg	UCL-NP	95% KM (t) UCL
	Chromium	mg/kg	4.1	5.8	27.5	5.8	mg/kg	UCL-G	95% Approximate Gamma UCL
	Cobalt	mg/kg	6.62	8.12	16.1	8.12	mg/kg	UCL-G	95% Approximate Gamma UCL
	Iron	mg/kg	24125	27988	44700	27988	mg/kg	UCL-G	95% Approximate Gamma UCL
	Manganese	mg/kg	285.1	327	474	327	mg/kg	UCL-N	95% Student's-t UCL
	Vanadium	mg/kg	69.3	85.5	162	85.5	mg/kg	UCL-G	95% Approximate Gamma UCL

µg/kg = microgram per kilogram
mg/kg = milligram per kilogram
J = qualifier for estimated value

Notes:
(1) Mean and upper confidence limit (UCL) concentrations are calculated using ProUCL version 4.1.00 for chemicals with at least 5 samples in a dataset and 4 detected values.
(2) Exposure point concentration is lower of maximum concentration and UCL.
(3) Rationale: UCL-N = upper confidence limit of mean of normal distribution
UCL-G = upper confidence limit of mean of gamma distribution
UCL-NP = upper confidence limit of mean of non-parametric distribution

TABLE B-3.3
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Point	Chemical of Potential Concern	Unit	Mean Concentration [1]	Upper Confidence Limit [1]	Maximum Concentration (Qualifier)	Exposure Point Concentration [2]			
						Value	Unit	Statistic	Rationale [3]
Groundwater	**Volatile Organic Compounds**								
	cis-1,2-Dichloroethene	µg/L	30.7	54.5	300	54.5	µg/L	UCL-NP	95% KM (t) UCL
	Tetrachloroethene	µg/L	0.54	0.99	8.5 J	0.99	µg/L	UCL-NP	95% KM (t) UCL
	trans-1,2-Dichloroethene	µg/L	1.5	2.3	13	2.3	µg/L	UCL-NP	95% KM (t) UCL
	Trichloroethene	µg/L	0.45	0.56	1.9	0.56	µg/L	UCL-NP	95% KM (t) UCL
	Vinyl Chloride	µg/L	0.25	NA	0.73	0.73	µg/L	Max	<4 detected values
	Inorganics								
	Aluminum	µg/L	397.8	2038	8190 J	2038	µg/L	UCL-NP	97.5% KM (Chebyshev) UCL
	Arsenic	µg/L	2.9	3.8	7.2	3.8	µg/L	UCL-NP	95% KM (t) UCL
	Barium	µg/L	176	204	346 J	204	µg/L	UCL-N	95% Student's-t UCL
	Chromium	µg/L	4.87	8.35	33.4	8.35	µg/L	UCL-NP	95% KM (t) UCL
	Cobalt	µg/L	0.7	1.1	6.5	1.1	µg/L	UCL-NP	95% KM (t) UCL
	Copper	µg/L	9.5	52.2	211	52.2	µg/L	UCL-NP	95% KM (t) UCL
	Iron	µg/L	1587	8196	16600	8196	µg/L	UCL-NP	99% KM (Chebyshev) UCL
	Manganese	µg/L	229	412	2340 J	412	µg/L	UCL-G	95% Adjusted Gamma UCL
	Vanadium	µg/L	12.5	17.0	68.2	17.0	µg/L	UCL-NP	95% KM (BCA) UCL

µg/L = microgram per liter J = qualifier for estimated value

Notes:
[1] Mean and upper confidence limit (UCL) concentrations are calculated using ProUCL version 4.1.00 for chemicals with at least 5 samples in a dataset and 4 detected values.
[2] Exposure point concentration is lower of maximum concentration and UCL.
[3] Rationale: UCL-G = upper confidence limit of mean of gamma distribution
UCL-NP = upper confidence limit of mean of non-parametric distribution

TABLE B-3.4
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Point	Chemical of Potential Concern	Unit	Mean Concentration [1]	Upper Confidence Limit [1]	Maximum Concentration (Qualifier)	Exposure Point Concentration [2]			
						Value	Unit	Statistic	Rationale [3]
Surface Water	**Volatile Organic Compounds**								
	Bromodichloromethane	µg/L	0.5	NA	1	1	µg/L	Max	<4 detected values
	Dibromochloromethane	µg/L	0.8	NA	1.3	1.3	µg/L	Max	<4 detected values

µg/L = microgram per liter

Notes:
[1] Mean and upper confidence limit (UCL) concentrations are calculated using ProUCL version 4.1.00 for chemicals with at least 5 samples in a dataset and 4 detected values.
[2] Exposure point concentration is lower of maximum concentration and UCL.
[3] Rationale: UCL-NP = upper confidence limit of mean of non-parametric distribution

TABLE B-3.5
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Point	Chemical of Potential Concern	Unit	Mean Concentration (1)	Upper Confidence Limit (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration (2)			
						Value	Unit	Statistic	Rationale (3)
Sediment	**Inorganics**								
	Arsenic	mg/kg	1.0	NA	2.7	2.7	mg/kg	Max	<4 detected values
	Chromium	mg/kg	3.6	4.7	6 J	4.7	mg/kg	UCL-N	95% Student's-t UCL
	Cobalt	mg/kg	3.9	5.3	7.1	5.3	mg/kg	UCL-N	95% Student's-t UCL
	Iron	mg/kg	8155	10517	13500 J	10517	mg/kg	UCL-N	95% Student's-t UCL
	Manganese	mg/kg	284	310	333	310	mg/kg	UCL-N	95% Student's-t UCL
	Vanadium	mg/kg	41.3	54.1	70.6 J	54.1	mg/kg	UCL-N	95% Modified-t UCL

µg/kg = microgram per kilogram
mg/kg = milligram per kilogram
J = qualifier for estimated value
NA = not available

Notes:
(1) Mean and upper confidence limit (UCL) concentrations are calculated using ProUCL version 4.1.00 for chemicals with at least 5 samples in a dataset and 4 detected values.
(2) Exposure point concentration is lower of maximum concentration and UCL.
(3) Rationale: UCL-N = upper confidence limit of mean of normal distribution
Max = maximum detected concentration

TABLE B-4.1

VALUES AND EQUATIONS USED FOR DAILY INTAKE CALCULATIONS

Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Intake Equation/ Model Name
							Value	Rationale/Reference	Value	Rationale/Reference	
Ingestion	Commercial/ Industrial	Adult	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Daily Intake (mg/kg-day) =
				CF	Conversion Factor	kg/mg	1E-06	--	1E-06	--	CS x CF x IR-S x EF x ED x
				IR-S	Ingestion Rate of Soil	mg/day	100	EPA 2002	50	EPA 1997	1/BW x 1/AT
				EF	Exposure Frequency	days/year	250	EPA 2004	219	EPA 2004	
				ED	Exposure Duration	years	25	EPA 2004	9	EPA 2004	
				BW	Body Weight	kg	70	EPA 2002	70	EPA 2002	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	9,125	EPA 1989	3,285	EPA 1989	
	Trespasser	Adolescent (7-12 yrs)	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Daily Intake (mg/kg-day) =
				CF	Conversion Factor	kg/mg	1E-06	--	1E-06	--	CS x CF x IR-S x EF x ED x
				IR-S	Ingestion Rate of Soil	mg/day	100	EPA 2002	50	(1)	1/BW x 1/AT
				EF	Exposure Frequency	days/year	100	EPA 2009	50	(2)	
				ED	Exposure Duration	years	6	EPA 1989	6	EPA 1989	
				BW	Body Weight	kg	36	EPA 1997(3)	36	EPA 1997(3)	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	
	Resident	Adult and Child (0-6 yrs)	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Daily Intake (mg/kg-day):
				CF	Conversion Factor	kg/mg	1E-06	--	1E-06	--	for nonmutagen =
				$IR\text{-}S_a$	Ingestion Rate of Soil - adult	mg/day	100	EPA 2002	50	EPA 2002	$CS \times CF \times \{(IR\text{-}S_a x ED_a / BW_a) +$
				$IR\text{-}S_c$	Ingestion Rate of Soil - child	mg/day	200	EPA 2002	100	EPA 2002	$(IR\text{-}S_c x ED_c / BW_c)\} \times EF \times 1/AT$
				EF	Exposure Frequency	days/year	350	EPA 2002	350	EPA 2002	
				ED_a	Exposure Duration - adult	years	24	EPA 2002	9	EPA 1997	for mutagen =
				ED_c	Exposure Duration - child	years	6	EPA 2002	6	EPA 2002	for RME: $CS \times \{(2xIR\text{-}S_c x10/BW_c)+$
				BW_a	Body Weight - adult	kg	70	EPA 2002	70	EPA 2002	$(4xIR\text{-}S_c x3/BW_c)+(10xIR\text{-}S_a x3/BW_a)$
				BW_c	Body Weight - child	kg	15	EPA 2002	15	EPA 2002	$+(14xIR\text{-}S_a x1/BW_a)\} \times EF \times CF / AT$
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	for CTE: $CS \times \{(2xIR\text{-}S_c x10/BW_c)+$
				$AT\text{-}N_a$	Averaging Time (Noncancer) - adult	days	8,760	EPA 1989	3,285	EPA 1989	$(4xIR\text{-}S_c x3/BW_c)+(9xIR\text{-}S_a x3/BW_a)\}$
				$AT\text{-}N_c$	Averaging Time (Noncancer) - child	days	2,190	EPA 1989	2,190	EPA 1989	$\times EF \times CF / AT$
	Construction Worker	Adult	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.2a or B-3.2b	Tables B-3.2a or B-3.2b	Not Evaluated		Daily Intake (mg/kg-day) =
				CF	Conversion Factor	kg/mg	1E-06	--			CS x CF x IR-S x EF x ED x
				IR-S	Ingestion Rate of Soil	mg/day	330	EPA 2002			1/BW x 1/AT
				EF	Exposure Frequency	days/year	100	(4)			
				ED	Exposure Duration	years	1	(4)			
				BW	Body Weight	kg	70	EPA 2002			
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989			
				AT-N	Averaging Time (Noncancer)	days	365	EPA 1989			
Dermal Contact	Commercial/ Industrial Worker	Adult	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Daily Intake (mg/kg-day) =
				CF	Conversion Factor	kg/mg	1E-06	--	1E-06	--	CS x CF x SA x AF x ABS x
				SA	Skin Surface Area Available for Contact	cm^2	3,300	EPA 2004	3,300	EPA 2004	EF x ED x 1/BW x 1/AT
				AF	Adherence Factor	mg/cm^2	0.2	EPA 2004	0.02	EPA 2004	
				ABS	Absorption Factor	unitless	chemical specific	Table B-4.5	chemical specific	Table B-4.5	
				EF	Exposure Frequency	days/year	250	EPA 2002	219	EPA 2004	
				ED	Exposure Duration	years	25	EPA 2002	9	EPA 2004	
				BW	Body Weight	kg	70	EPA 2002	70	EPA 2002	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	9,125	EPA 1989	3,285	EPA 1989	
	Trespasser	Adolescent (7-12 yrs)	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Daily Intake (mg/kg-day) =
				CF	Conversion Factor	kg/mg	1E-06	--	1E-06	--	CS x CF x SA x AF x ABS x
				SA	Skin Surface Area Available for Contact	cm^2	3,600	EPA 2004(5)	3,600	EPA 2004(5)	EF x ED x 1/BW x 1/AT
				AF	Adherence Factor	mg/cm^2	0.07	EPA 2004	0.01	EPA 2004	
				ABS	Absorption Factor	unitless	chemical specific	Table B-4.5	chemical specific	Table B-4.5	
				EF	Exposure Frequency	days/year	100	EPA 2009	50	(1)	
				ED	Exposure Duration	years	6	EPA 1989	6	EPA 1989	
				BW	Body Weight	kg	36	EPA 1997(3)	36	EPA 1997(3)	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	

TABLE B-4.1

VALUES AND EQUATIONS USED FOR DAILY INTAKE CALCULATIONS

Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Intake Equation/ Model Name
							Value	Rationale/Reference	Value	Rationale/Reference	
Dermal Contact	Resident	Adult and Child (0-6 yrs)	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Daily Intake (mg/kg-day):
				CF	Conversion Factor	kg/mg	1E-06	--	1E-06	--	for nonmutagen =
				SA_a	Skin Surface Area Available for Contact - adult	cm^2	5,700	EPA 2004	5,700	EPA 2004	CS x CF x {(SA_axAF_axED_ax1/BWa) +
				SA_c	Skin Surface Area Available for Contact - child	cm^2	2,800	EPA 2004	2,800	EPA 2004	(SA_cxAF_cxED_cx1/BW_c)} x ABS x
				AF_a	Adherence Factor - adult	mg/cm^2	0.07	EPA 2004	0.01	EPA 2004	EF x 1/AT
				AF_c	Adherence Factor - child	mg/cm^2	0.2	EPA 2004	0.04	EPA 2004	
				ABS	Absorption Factor	unitless	chemical specific	Table B-4.5	chemical specific	Table B-4.5	for mutagen =
				EF	Exposure Frequency	days/year	350	EPA 2004	350	EPA 2004	for RME: CS x {(2xSA_cxAF_cx10/BW_c)+
				ED_a	Exposure Duration - adult	years	24	EPA 2004	9	EPA 2004	(4xSA_cxAF_cx3/BW_c)+(10xSA_axAF_ax3/BW_a)+
				ED_c	Exposure Duration - child	years	6	EPA 2004	6	EPA 2002	(14xSA_axAF_ax1/BW_a)} x ABS x EF x CF / AT
				BW_a	Body Weight - adult	kg	70	EPA 2004	70	EPA 2004	for CTE: CS x {(2xSA_cxAF_cx10/BW_c)+
				BW_c	Body Weight - child	kg	15	EPA 2004	15	EPA 2004	(4xSA_cxAF_cx3/BW_c)+(9xSA_axAF_ax3/BW_a)}
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	x ABS x EF x CF / AT
				$AT\text{-}N_a$	Averaging Time (Noncancer) - adult	days	8,760	EPA 1989	3,285	EPA 1989	
				$AT\text{-}N_c$	Averaging Time (Noncancer) - child	days	2,190	EPA 1989	2,190	EPA 1989	
	Construction Worker	Adult	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.2a or B-3.2b	Tables B-3.2a or B-3.2b	Not Evaluated		Daily Intake (mg/kg-day) =
				CF	Conversion Factor	kg/mg	1E-06	--			CS x CF x SA x AF x ABS x
				SA	Skin Surface Area Available for Contact	cm^2	3,300	EPA 2004			EF x ED x 1/BW x 1/AT
				AF	Adherence Factor	mg/cm^2	0.3	EPA 2004			
				ABS	Absorption Factor	unitless	chemical specific	Table B-4.5			
				EF	Exposure Frequency	days/year	100	(4)			
				ED	Exposure Duration	years	1	(4)			
				BW	Body Weight	kg	70	EPA 2004			
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989			
				AT-N	Averaging Time (Noncancer)	days	365	EPA 1989			
Inhalation	Commercial/ Industrial Worker	Adult	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Exposure Concentration (mg/m^3) =
				CA	Chemical Concentration in Air	mg/m^3	calculated	calculated	calculated	calculated	CA x ET x EF x ED x 1/AT
				ET	Exposure Time	hrs/day	8	EPA 2009	4	(2)	where:
				EF	Exposure Frequency	days/year	250	EPA 2002	219	EPA 2004	CA = CS/PEF
				ED	Exposure Duration	years	25	EPA 2002	9	EPA 2004	
				PEF	Particulate Emission Factor	m^3/kg	1.36E+09	EPA 2002	1.36E+09	EPA 2002	
				AT-C	Averaging Time (Cancer)	hrs	613,200	EPA 1989	613,200	EPA 1989	
				AT-N	Averaging Time (Noncancer)	hrs	219,000	EPA 1989	78,840	EPA 1989	
	Trespasser	Adolescent (7-12 yrs)	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Exposure Concentration (mg/m^3):
				CA	Chemical Concentration in Air	mg/m^3	calculated	calculated	calculated	calculated	for cancer =
				ET	Exposure Time	hrs/day	2	EPA 2009	1	EPA 2009	CA x ET x EF x ED x 1/AT
				EF	Exposure Frequency	days/year	100	EPA 2009	50	(1)	for noncancer =
				ED	Exposure Duration	years	6	EPA 1989	6	EPA 1989	CA
				PEF	Particulate Emission Factor	m^3/kg	1.36E+09	EPA 2002	1.36E+09	EPA 2002	where:
				AT-C	Averaging Time (Cancer)	hrs	613,200	EPA 1989	613,200	EPA 1989	CA = CS/PEF
				AT-N	Averaging Time (Noncancer)	hrs	52,560	EPA 1989	52,560	EPA 1989	
	Resident	Adult and Child (0-6 yrs)	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Tables B-3.1a or B-3.1b	Exposure Concentration (mg/m^3) =
				CA	Chemical Concentration in Air	mg/m^3	calculated	calculated	calculated	calculated	for nonmutagen =
				ET_a	Exposure Time - adult	hrs/day	24	EPA 2009	24	EPA 2009	CA x ET x EF x ED x 1/AT
				ET_c	Exposure Time - child	hrs/day	24	EPA 2009	24	EPA 2009	for mutagen =
				EF	Exposure Frequency	days/year	350	EPA 2002	350	EPA 2002	for RME: CS x {(2 x 10)+(4 x 3)+(10 x 3)+
				ED_a	Exposure Duration - adult	years	24	EPA 2002	9	EPA 1997	(14 x 1)} x ET x EF / AT
				ED_c	Exposure Duration - child	years	6	EPA 2002	6	EPA 2002	for CTE: CS x {(2 x 10)+(4 x 3)+(9 x 3)}
				PEF	Particulate Emission Factor	m^3/kg	1.36E+09	EPA 2002	1.36E+09	EPA 2002	x ET x EF / AT
				AT-C	Averaging Time (Cancer)	hrs	613,200	EPA 1989	613,200	EPA 1989	where:
				$AT\text{-}N_a$	Averaging Time (Noncancer) - adult	hrs	210,240	EPA 1989	78,840	EPA 1989	CA = CS/PEF
				$AT\text{-}N_c$	Averaging Time (Noncancer) - child	hrs	52,560	EPA 1989	52,560	EPA 1989	

TABLE B-4.1

VALUES AND EQUATIONS USED FOR DAILY INTAKE CALCULATIONS

Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure Medium:	Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Intake Equation/ Model Name
							Value	Rationale/Reference	Value	Rationale/Reference	
Inhalation	Construction Worker	Adult	Puerto Rico Beverage/ Former Sugar Mill	CS	Chemical Concentration in Soil	mg/kg	Tables B-3.2a or B-3.2b	Tables B-3.2a or B-3.2b	Not Evaluated		Exposure Concentration (mg/m^3) = CA x ET x EF x ED x 1/AT where: CA = CS/PEF
				CA	Chemical Concentration in Air	mg/m^3	calculated	calculated			
				ET	Exposure Time	hrs/day	8	EPA 2009			
				EF	Exposure Frequency	days/year	100	(4)			
				ED	Exposure Duration	years	1	(4)			
				PEF	Particulate Emission Factor	m^3/kg	1.36E+09	EPA 2002			
				AT-C	Averaging Time (Cancer)	hrs	613,200	EPA 1989			
				AT-N	Averaging Time (Noncancer)	hrs	8,760	EPA 1989			

RME = Reasonable Maximum Exposure; CTE = Central Tendency Exposure

Notes:
(1) CTE ingestion rate is assumed to be one half the RME value.
(2) assumes one-half RME exposure frequency or exposure time
(3) based on the weighted average weight for children 7 to 12 years in age
(4) assumes 5 months (100 workdays) per year for one year
(5) based on the weighted average surface area for head, hands, forearms, lower legs, and feet for children ages 7 to 12 years

Sources:

EPA 1989. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
EPA 1991. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.
EPA 1997. Exposure Factors Handbook, Vols. I, II, and III. EPA/600/P-95/002Fa, 002Fb, and 002Fc.
EPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.
EPA 2004. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment Final. EPA/540/R/99/005.
EPA 2009. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment. EPA-540-R-070-002.

TABLE B-4.2
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Intake Equation/ Model Name
							Value	Rationale/ Reference	Value	Rationale/ Reference	
Ingestion	Commercial/ Industrial Worker	Adult	Tap Water	CW	Chemical Concentration in Water	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Daily Intake (mg/kg-day) = CW x CF1 x IR-W x EF x ED x 1/BW x 1/AT
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	
				IR-W	Ingestion Rate of Water	L/day	1	EPA 1991	1	EPA 1991	
				EF	Exposure Frequency	days/year	250	EPA 2002	219	EPA 2004	
				ED	Exposure Duration	years	25	EPA 2002	9	EPA 2004	
				BW	Body Weight	kg	70	EPA 1991	70	EPA 1991	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	9,125	EPA 1989	3,285	EPA 1989	
	Resident	Adult/Child	Tap Water	CW	Chemical Concentration in Water	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Daily Intake (mg/kg-day):
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	for nonmutagen =
				$IR\text{-}W_a$	Ingestion Rate of Water, adult	L/day	2	EPA 1991	1.4	EPA 1997	$CW \times CF1 \times \{(IR\text{-}W_a \times ED_a \times 1/BW_a +$
				$IR\text{-}W_c$	Ingestion Rate of Water, child	L/day	1	EPA 1997	0.4	EPA 1997	$IR\text{-}W_c \times ED_c \times 1/BW_c)\} \times EF \times 1/AT$
				BW_a	Body Weight, adult	kg	70	EPA 2002	70	EPA 2002	for mutagen =
				BW_c	Body Weight, child	kg	15	EPA 2002	15	EPA 2002	for RME: $CW \times CF1 \times \{(2xIR\text{-}W_cx10/BW_c)+$
				ED_a	Exposure Duration, adult	years	24	EPA 2004	9	EPA 1997	$(4xIR\text{-}W_cx3/BW_c)+(10xIR\text{-}W_ax3/BW_a)+$
				ED_c	Exposure Duration, child	years	6	EPA 2004	6	EPA 1991	$(14xIR\text{-}W_ax1/BW_a)\} \times EF \times 1/AT$
				EF	Exposure Frequency	days/year	350	EPA 2002	350	EPA 2002	for CTE: $CW \times CF1 \times \{(2xIR\text{-}W_cx10/BW_c)+$
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	$(4xIR\text{-}W_cx3/BW_c)+(9xIR\text{-}W_ax3/BW_a)\} \times EF \times 1/AT$
				$AT\text{-}N_a$	Averaging Time (Noncancer) - adult	days	8,760	EPA 1989	3,285	EPA 1989	
				$AT\text{-}N_c$	Averaging Time (Noncancer) - child	days	2,190	EPA 1989	2,190	EPA 1989	
Dermal Contact	Commercial/ Industrial Worker	Adult	Tap Water (Showering and Bathing)	CW	Chemical Concentration in Water	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Dermally Absorbed Dose (mg/kg-day) = $SA \times DA_{event} \times EDx\ 1/BW \times EF \times 1/AT$
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	
				SA	Skin Surface Area Available for Contact	cm^2	18,000	EPA 2004	18,000	EPA 2004	
				DA_{event}	Absorbed dose	mg/cm^2	chemical specific	Table B-4.5	chemical specific	Table B-4.5	
				CF2	Conversion Factor 2	L/cm^3	0.001	--	0.001	--	
				ET	Exposure Time	hr/day	0.58	EPA 2004	0.25	EPA 2004	
				EF	Exposure Frequency	days/year	250	EPA 2002	219	EPA 2004	
				ED	Exposure Duration	years	25	EPA 2002	9	EPA 2004	
				BW	Body Weight	kg	70	EPA 2004	70	EPA 2004	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	9,125	EPA 1989	3,285	EPA 1989	
	Resident	Adult/Child	Tap Water (Showering and Bathing)	CW	Chemical Concentration in Water	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Dermally Absorbed Dose (mg/kg-day) =
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	for nonmutagen =
				SA_a	Skin Surface Area Available for Contact - adult	cm^2	18,000	EPA 2004	18,000	EPA 2004	$\{(SA_a xDA_{event\text{-}c} xED_a x1/BW_a)+$
				SA_c	Skin Surface Area Available for Contact - child	cm^2	6,600	EPA 2004	6,600	EPA 2004	$(SA_c xDA_{event\text{-}c} xED_c x1/BW_c)\} \times EF \times 1/AT$
				DA_{event}	Absorbed dose	mg/cm^2	chemical specific	Table B-4.5	chemical specific	Table B-4.5	
				CF2	Conversion Factor 2	L/cm^3	0.001	--	0.001	--	for mutagen =
				ET_a	Exposure Time - adult	hr/day	0.58	EPA 2004	0.25	EPA 2004	for RME: $\{(2xSA_c xDA_{event\text{-}c} x10/BW_c)+$
				ET_c	Exposure Time - child	hr/day	1	EPA 2004	0.33	EPA 2004	$(4xSA_c xDA_{event\text{-}c} x3/BW_c)+(10xSA_a xDA_{event\text{-}a} x3/BW_a)$
				EF	Exposure Frequency	days/year	350	EPA 2004	350	EPA 2004	$+(14xSA_a xDA_{event\text{-}a} x1/BW_a)\} \times EF \times 1/AT$
				ED_a	Exposure Duration - adult	years	24	EPA 2004	9	EPA 2004	for CTE: $\{(2xSA_c xDA_{event\text{-}c} x10/BW_c)+$
				ED_c	Exposure Duration - child	years	6	EPA 2004	6	EPA 1991	$(4xSA_c xDA_{event\text{-}c} x3/BW_c)+(9xSA_a xDA_{event\text{-}a} x3/BW_a)\}$
				BW_a	Body Weight	kg	70	EPA 2004	70	EPA 2004	$\times EF \times 1/AT$
				BW_c	Body Weight - child	kg	15	EPA 2004	15	EPA 2004	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				$AT\text{-}N_a$	Averaging Time (Noncancer) - adult	days	8,760	EPA 1989	3,285	EPA 1989	
				$AT\text{-}N_c$	Averaging Time (Noncancer) - child	days	2,190	EPA 1989	2,190	EPA 1989	

TABLE B-4.2
VALUES USED FOR DAILY INTAKE CALCULATIONS FOR GROUNDWATER EXPOSURE PATHWAYS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Intake Equation/ Model Name
							Value	Rationale/ Reference	Value	Rationale/ Reference	
Inhalation	Commercial/ Industrial Worker	Adult	Tap Water (Showering and Bathing)	CW	Chemical concentration in groundwater	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Exposure Concentration (mg/m^3) = CA x CF x ET x ED x EF x 1/AT
				CA	Chemical concentration in air	$\mu g/m^3$	Table D-3	Table D-3	Table D-3	Table D-3	
				CF	Conversion factor	mg/µg	0.001	-	0.001	-	
				ET	Exposure time	hr/day	0.58	EPA 2004	0.25	EPA 2004	
				EF	Exposure frequency	days/yr	250	EPA 2002	219	EPA 2004	
				ED	Exposure Duration	years	25	EPA 2002	9	EPA 2004	
				AT-C	Averaging time (Cancer)	hrs	613,200	EPA 2009	613,200	EPA 2009	
				AT-N	Averaging time (Noncancer)	hrs	219,000	EPA 2009	78,840	EPA 2009	
	Resident	Adult/Child	Tap Water (Showering and Bathing)	CW	Chemical concentration in groundwater	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Exposure Concentration (mg/m^3) = CA x CF x {(ET_a x ED_a)+(ET_c x ED_c)} x EF x 1/AT
				CA	Chemical concentration in air	$\mu g/m^3$	Tables D-3 or D-4	Tables D-3 or D-4	Tables D-3 or D-4	Tables D-3 or D-4	
				CF	Conversion factor	mg/µg	0.001	-	0.001	-	
				ET_a	Exposure time - adult	hr/day	0.58	EPA 2004	0.25	EPA 2004	EC (mg/m^3) for mutagen = for RME: CF x {(CA_cx2x10xET_c)+(CA_cx4x3xET_c)+ (CA_ax10x3xET_a)+(CA_ax14x1xET_a)} x EF / AT
				ET_c	Exposure time - child	hr/day	1	EPA 2004	0.33	EPA 2004	
				EF	Exposure frequency	days/yr	350	EPA 2004	350	EPA 2004	
				ED_a	Exposure Duration, adult	years	24	EPA 2004	9	EPA 1997	
				ED_c	Exposure duration, child	years	6	EPA 2004	6	EPA 1991	for CTE: CF x {(CA_cx2x10xET_c)+(CA_cx4x3xET_c)+ (CA_ax9x3xET_a)} x EF / AT
				AT-C	Averaging time (Cancer)	hrs	613,200	EPA 2009	613,200	EPA 2009	
				$AT\text{-}N_a$	Averaging time (Noncancer) - adult	hrs	210,240	EPA 2009	78,840	EPA 2009	
				$AT\text{-}N_c$	Averaging time (Noncancer) - child	hrs	52,560	EPA 2009	52,560	EPA 2009	

RME = Reasonable Maximum Exposure; CTE = Central Tendency Exposure

Sources:

EPA 1989. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002
EPA 1991. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03
EPA 1997. Exposure Factors Handbook, Vols. I, II, and III. EPA/600/P-95/002Fa, 002Fb, and 002Fc.
EPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24
EPA 2004. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment Final. EPA/540/R/99/005
EPA 2009. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment. EPA-540-R-070-002

TABLE B-4.3
VALUES AND EQUATIONS USED FOR DAILY INTAKE CALCULATIONS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Chronic Daily Intake (CDI)
							Value	Rationale/ Reference	Value	Rationale/ Reference	
Ingestion	Recreational User	Adolescent (7-12 yrs)	Maunabo River	CW	Chemical Concentration in Water	µg/L	Table B-3.4	Table B-3.4	Table B-3.4	Table B-3.4	Daily Intake (mg/kg-day) = CW x CF1 x IR-W x EF x ED x 1/BW x 1/AT
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	
				IR-W	Ingestion Rate of Water	L/day	0.05	EPA 1989	0.05	EPA 1989	
				EF	Exposure Frequency	days/year	175	EPA 2012	100	EPA 2012	
				ED	Exposure Duration	years	6	EPA 1989	6	EPA 1989	
				BW	Body Weight	kg	36	EPA 1997(1)	36	EPA 1997(1)	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	
	Resident	Adult/Child	Tap Water	CW	Chemical Concentration in Water	µg/L	Table B-3.4	Table B-3.4	Table B-3.4	Table B-3.4	Daily Intake (mg/kg-day): CW x CF1 x {(IR-W_a x ED_a x 1/BW_a + IR-W_c x ED_c x 1/BW_c)} x EF x 1/AT
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	
				IR-W_a	Ingestion Rate of Water, adult	L/day	2	EPA 1991	1.4	EPA 1997	
				IR-W_c	Ingestion Rate of Water, child	L/day	1	EPA 1997	0.4	EPA 1997	
				BW_a	Body Weight, adult	kg	70	EPA 2002	70	EPA 2002	
				BW_c	Body Weight, child	kg	15	EPA 2002	15	EPA 2002	
				ED_a	Exposure Duration, adult	years	24	EPA 2004	9	EPA 1997	
				ED_c	Exposure Duration, child	years	6	EPA 2004	6	EPA 1991	
				EF	Exposure Frequency	days/year	350	EPA 2002	350	EPA 2002	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N_a	Averaging Time (Noncancer) - adult	days	8,760	EPA 1989	3,285	EPA 1989	
				AT-N_c	Averaging Time (Noncancer) - child	days	2,190	EPA 1989	2,190	EPA 1989	
Dermal Contact	Recreational User	Adolescent (7-12 yrs)	Maunabo River	CW	Chemical Concentration in Water	µg/L	Table B-3.4	Table B-3.4	Table B-3.4	Table B-3.4	Dermally Absorbed Dose (mg/kg-day) = SA x DA_{event} x EF x ED x 1/BW x 1/AT
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	
				SA	Skin Surface Area Available for Contact	cm^2	11,000	EPA 2004	11,000	EPA 2004	
				DA_{event}	Absorbed dose	mg/cm^2	chemical specific	Table B-4.5	chemical specific	Table B-4.5	
				CF2	Conversion Factor 2	L/cm^3	0.001	--	0.001	--	
				ET	Exposure Time	hrs/day	1	(2)	1	(2)	
				EF	Exposure Frequency	days/year	175	EPA 2012	100	EPA 2012	
				ED	Exposure Duration	years	6	EPA 1989	6	EPA 1989	
				BW	Body Weight	kg	36	EPA 1997(1)	36	EPA 1997(1)	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	
	Resident	Adult/Child	Tap Water (Showering and Bathing)	CW	Chemical Concentration in Water	µg/L	Table B-3.4	Table B-3.4	Table B-3.4	Table B-3.4	Dermally Absorbed Dose (mg/kg-day) = {(SA_ax$DA_{event-a}$xED_ax1/BW_a)+ (SA_cx$DA_{event-c}$xED_cx1/BW_c)} x EF x 1/AT
				CF1	Conversion Factor 1	mg/µg	0.001	--	0.001	--	
				SA_a	Skin Surface Area Available for Contact - adult	cm^2	18,000	EPA 2004	18,000	EPA 2004	
				SA_c	Skin Surface Area Available for Contact - child	cm^2	6,600	EPA 2004	6,600	EPA 2004	
				DA_{event}	Absorbed dose	mg/cm^2	chemical specific	Table B-4.5	chemical specific	Table B-4.5	
				CF2	Conversion Factor 2	L/cm^3	0.001	--	0.001	--	
				ET_a	Exposure Time - adult	hr/day	0.58	EPA 2004	0.25	EPA 2004	
				ET_c	Exposure Time - child	hr/day	1	EPA 2004	0.33	EPA 2004	
				EF	Exposure Frequency	days/year	350	EPA 2004	350	EPA 2004	
				ED_a	Exposure Duration - adult	years	24	EPA 2004	9	EPA 2004	
				ED_c	Exposure Duration - child	years	6	EPA 2004	6	EPA 1991	
				BW_a	Body Weight	kg	70	EPA 2004	70	EPA 2004	
				BW_c	Body Weight - child	kg	15	EPA 2004	15	EPA 2004	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N_a	Averaging Time (Noncancer) - adult	days	8,760	EPA 1989	3,285	EPA 1989	
				AT-N_c	Averaging Time (Noncancer) - child	days	2,190	EPA 1989	2,190	EPA 1989	

TABLE B-4.3
VALUES AND EQUATIONS USED FOR DAILY INTAKE CALCULATIONS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Chronic Daily Intake (CDI)
							Value	Rationale/ Reference	Value	Rationale/ Reference	
Inhalation	Resident	Adult/Child	Tap Water (Showering and Bathing)	CW	Chemical concentration in groundwater	µg/L	Table B-3.4	Table B-3.4	Table B-3.4	Table B-3.4	Exposure Concentration (mg/m^3) = CA x CF x {(ET_a x ED_a)+(ET_c x ED_c)} x EF x 1/AT
				CA	Chemical concentration in air	$\mu g/m^3$	Tables D-5 or D-6	Tables D-5 or D-6	Tables D-5 or D-6	Tables D-5 or D-6	
				CF	Conversion factor	mg/µg	0.001	-	0.001	-	
				ET_a	Exposure time - adult	hr/day	0.58	EPA 2004	0.25	EPA 2004	
				ET_c	Exposure time - child	hr/day	1	EPA 2004	0.33	EPA 2004	
				EF	Exposure frequency	days/yr	350	EPA 2004	350	EPA 2004	
				ED_a	Exposure Duration, adult	years	24	EPA 2004	9	EPA 1997	
				ED_c	Exposure duration, child	years	6	EPA 2004	6	EPA 1991	
				AT-C	Averaging time (Cancer)	hrs	613,200	EPA 2009	613,200	EPA 2009	
				AT-N_a	Averaging time (Noncancer) - adult	hrs	210,240	EPA 2009	78,840	EPA 2009	
				AT-N_c	Averaging time (Noncancer) - child	hrs	52,560	EPA 2009	52,560	EPA 2009	

RME = Reasonable Maximum Exposure; CTE = Central Tendency Exposure

Notes:

(1) based on the weighted average weight for children 7 to 12 years in age

(1) assume children spend 1 hour per day swimming

Sources:

EPA 1989. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002

EPA 1991. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03

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EPA 2009. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment. EPA-540-R-070-002

EPA 2012. Conference call with Julie McPherson of EPA on February 27.

TABLE B-4.4
VALUES AND EQUATIONS USED FOR DAILY INTAKE CALCULATIONS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Unit	RME		CTE		Chronic Daily Intake (CDI)
							Value	Rationale/ Reference	Value	Rationale/ Reference	
Ingestion	Recreational User	Adolescent (7-12 yrs)	Maunabo River	CS	Chemical Concentration in Sediment	mg/kg	Table B-3.5	Table B-3.5	Table B-3.5	Table B-3.5	Daily Intake (mg/kg-day) = CS x CF x IR-S x EF x ED x 1/BW x 1/AT
				CF	Conversion Factor 1	kg/mg	1E-06	--	1E-06	--	
				IR-S	Ingestion Rate of Sediment	mg/day	100	EPA 2002[1]	50	EPA 2002[1]	
				EF	Exposure Frequency	days/year	175	EPA 2012	100	EPA 2012	
				ED	Exposure Duration	years	6	EPA 1989	6	EPA 1989	
				BW	Body Weight	kg	36	EPA 1997[2]	36	EPA 1997[2]	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	
Dermal Contact	Recreational User	Adolescent (7-12 yrs)	Maunabo River	CS	Chemical Concentration in Sediment	mg/kg	Table B-3.5	Table B-3.5	Table B-3.5	Table B-3.5	Daily Intake (mg/kg-day) = CS x CF x SA x AF x ABS x EF x ED x 1/BW x 1/AT
				CF	Conversion Factor 1	kg/mg	1E-06	--	1E-06	--	
				SA	Skin Surface Area Available for Contact	cm^2	4,400	EPA 2004[3]	4,400	EPA 2004[3]	
				AF	Adherence Factor	mg/cm^2	0.2	EPA 2004[4]	0.2	EPA 2004[4]	
				ABS	Absorption Factor	unitless	chemical specific	Table B-4.5	chemical specific	Table B-4.5	
				EF	Exposure Frequency	days/year	175	EPA 2012	100	EPA 2012	
				ED	Exposure Duration	years	6	EPA 1989	6	EPA 1989	
				BW	Body Weight	kg	36	EPA 1997[2]	36	EPA 1997[2]	
				AT-C	Averaging Time (Cancer)	days	25,550	EPA 1989	25,550	EPA 1989	
				AT-N	Averaging Time (Noncancer)	days	2,190	EPA 1989	2,190	EPA 1989	

RME = Reasonable Maximum Exposure; CTE = Central Tendency Exposure

Notes:
[1] based on the soil ingestion rate for children. CTE is assumed to be one half the RME value.
[2] based on the weighted average weight for children 7 to 12 years in age
[3] based on the weighted average surface area for head, hands, forearms, lower legs, and feet for children ages 6 to <21 years
[4] based on adherence factor for children playing in wet soil

Sources:

EPA 1989. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002
EPA 1997. Exposure Factors Handbook, Vols. I, II, and III. EPA/600/P-95/002Fa, 002Fb, and 002Fc.
EPA 2004. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment Final. EPA/540/R/99/005
EPA 2009. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment. EPA-540-R-070-002
EPA 2012. Conference call with Julie McPherson of EPA on February 27.

TABLE B-4.5
CHEMICAL-SPECIFIC INFORMATION USED FOR DAILY INTAKE CALCULATIONS
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical	Dermal Absorption Fraction [1] (Unitless)	Permeability Coefficient [1] (cm/hr)	Fraction absorbed water[1] Unitless	Lag time per event[1] (hr/event)	Time to reach steady state[1] (hr)	B[1] (Unitless)	DA_{event}[2] Commercial/ Industrial Worker (mg/cm^2)	DA_{event}[2] Recreational User (7-12 yrs) (mg/cm^2)	DA_{event}[2] Resident (mg/cm^2)	Henry's Law Constant[3] (atm-m^3/mole)	Diffusivity in Air[3] (cm^2/s)	Diffusivity in Water[3] (cm^2/s)	Fraction Volatilized[4] Unitless
Volatile Organic Compounds													
Bromodichloromethane	NA	4.6E-03	1.0E+00	8.8E-01	2.1E+00	0.0E+00	NA	1.2E-08	NA	2.1E-03	5.6E-02	1.1E-05	5.4E-01
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.1E-03	8.8E-02	1.1E-05	5.6E-01
Dibromochloromethane	NA	3.2E-03	1.0E+00	1.6E+00	3.8E+00	0.0E+00	NA	1.4E-08	NA	7.8E-04	3.7E-02	1.1E-05	5.4E-01
Tetrachloroethene	NA	3.3E-02	1.0E+00	9.1E-01	2.2E+00	2.0E-01	6.6E-08	NA	7.0E-08	1.8E-02	5.0E-02	9.5E-06	5.0E-01
trans-1,2-Dichloroethene	NA	7.7E-03	1.0E+00	3.7E-01	8.9E-01	0.0E+00	2.3E-08	NA	2.4E-08	4.1E-03	8.8E-02	1.1E-05	5.6E-01
Trichloroethene	NA	1.2E-02	1.0E+00	5.8E-01	1.4E+00	1.0E-01	1.1E-08	NA	1.2E-08	9.9E-03	6.9E-02	1.0E-05	5.3E-01
Vinyl Chloride	NA	5.6E-03	1.0E+00	2.4E-01	5.7E-01	0.0E+00	4.3E-09	NA	4.7E-09	2.8E-02	1.1E-01	1.2E-05	5.9E-01
Semi-volatile Organic Compounds													
Benzo(a)pyrene	1.3E-01	7.0E-01	1.0E+00	2.7E+00	1.2E+01	4.3E+00	NA	NA	NA	4.6E-07	4.8E-02	5.6E-06	NA
Dibenzo(a,h)anthracene	1.3E-01	1.5E+00	6.0E-01	3.9E+00	1.8E+01	9.7E+00	NA	NA	NA	1.4E-07	4.5E-02	5.2E-06	NA
Inorganics													
Aluminum	NA	1.0E-03	NA	NA	NA	NA	1.2E-06	NA	1.4E-06	NA	NA	NA	NA
Arsenic	3.0E-02	1.0E-03	NA	NA	NA	NA	2.2E-09	NA	2.5E-09	NA	NA	NA	NA
Barium	NA	1.0E-03	NA	NA	NA	NA	1.2E-07	NA	1.4E-07	NA	NA	NA	NA
Chromium	NA	1.0E-03	NA	NA	NA	NA	4.8E-09	NA	5.5E-09	NA	NA	NA	NA
Cobalt	NA	4.0E-04	NA	NA	NA	NA	2.5E-10	NA	2.9E-10	NA	NA	NA	NA
Copper	NA	1.0E-03	NA	NA	NA	NA	3.0E-08	NA	3.5E-08	NA	NA	NA	NA
Iron	NA	1.0E-03	NA	NA	NA	NA	4.8E-06	NA	5.4E-06	NA	NA	NA	NA
Lead	NA	1.0E-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	1.0E-03	NA	NA	NA	NA	2.4E-07	NA	2.7E-07	NA	NA	NA	NA
Thallium	NA	1.0E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	1.0E-03	NA	NA	NA	NA	9.8E-09	NA	1.1E-08	NA	NA	NA	NA

NA - Not applicable
Notes:
[1] Source: EPA 2004. Risk Assessment Guidance for Superfund. Part E.
[2] Absorbed dose per event is calculated using Equations 3.2, 3.3, and 3.4 from EPA 2004) (p.3-4)
for organics:

$$\text{If } t_{event} \le t^*, DA_{event} = 2FA \times K_p \times C_W \sqrt{\frac{6\tau_{event} \times t_{event}}{\pi}} \qquad \text{If } t_{event} > t^*, DA_{event} = FA \times K_p \times C_W \left[\frac{t_{event}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

for inorganics:

$$DA_{event} = K_p \times C_W \times t_{event}$$

Where:
DA_{event} = absorbed dose per event, mg/cm^2
FA = fraction absorbed water
K_p = permeability coefficient, cm/hr
CW = chemical concentration in water, µg/L (Tables B-3.3 and B-3.4)
τ_{event} = lag time per event, hr
t_{event} = event duration, hr
t* = time to reach steady-state, hr
B = dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis
[3] Source: EPA 2011. Regional Screening Levels for Chemical Contaminanats at Superfund Sites. June.
[4] Estimated for volatile chemicals using Equation 5 from Schaum et al (1994) (p. 308), with radon as the reference chemical (j):

$$f_i = f_j \times \frac{\left(2.5/D_W^{0.67} + RT/D_a^{0.67}H\right)_j}{\left(2.5/D_W^{0.67} + RT/D_a^{0.67}H\right)_i}$$

Where:
f_i = volatilization fraction for chemical i
f_j = volatilization fraction for chemical j = Radon
D_a = diffusion coefficient in air, m^2/s
D_w = diffusion coefficient in water, m^2/s
D_a for Radon = 2.0×10^{-5}
D_w for Radon = 1.4×10^{-9}
R = gas constant, atm-m^3/mol-K = 8.21×10^{-5}
H = Henry's law constant, atm-m^3/mol
T = temperature, K = 293

TABLE B-5.1

NONCANCER TOXICITY DATA - ORAL/DERMAL

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal [1]	Absorbed RfD for Dermal [2]		Primary Target Organ	Combined Uncertainty/ Modifying Factor	Source	Date [3]
		Value	Unit		Value	Unit				
Volatile Organic Compounds										
Bromodichloromethane	Chronic	2.0E-02	mg/kg-day	1	2.0E-02	mg/kg-day	Liver	1,000	IRIS	12/2/2011
cis-1,2-Dichloroethene	Chronic	2.0E-03	mg/kg-day	1	2.0E-03	mg/kg-day	Kidney	3,000	IRIS	12/2/2011
Dibromochloromethane	Chronic	2.0E-02	mg/kg-day	1	2.0E-02	mg/kg-day	Liver	1,000	IRIS	12/2/2011
Tetrachloroethene	Chronic	6.0E-03	mg/kg-day	1	6.0E-03	mg/kg-day	Liver	1,000	IRIS	3/20/2012
trans-1,2-Dichloroethene	Chronic	2.0E-02	mg/kg-day	1	2.0E-02	mg/kg-day	Blood	3,000	IRIS	12/2/2011
Trichloroethene	Chronic	5.0E-04	mg/kg-day	1	5.0E-04	mg/kg-day	Heart/ Immunogical/ Developmental/Kidney	10 to 1,000	IRIS	12/2/2011
Vinyl Chloride	Chronic	3.0E-03	mg/kg-day	1	3.0E-03	mg/kg-day	Liver	30	IRIS	12/2/2011
Semi-volatile Organic Compounds										
Benzo(a)pyrene	Chronic	NA	NA	1	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	Chronic	NA	NA	1	NA	NA	NA	NA	NA	NA
Inorganics										
Aluminum	Chronic	1.0E+00	mg/kg-day	1	1.0E+00	mg/kg-day	Neurological	100	PPRTV	10/23/2006
Arsenic	Chronic	3.0E-04	mg/kg-day	1	3.0E-04	mg/kg-day	Skin	3	IRIS	12/2/2011
Barium	Chronic	2.0E-01	mg/kg-day	0.07	1.4E-02	mg/kg-day	Kidney	300	IRIS	12/2/2011
Chromium[4]	Chronic	3.0E-03	mg/kg-day	0.025	7.5E-05	mg/kg-day	None reported	300	IRIS	12/2/2011
Cobalt	Chronic	3.0E-04	mg/kg-day	1	3.0E-04	mg/kg-day	Thyroid	3,000	PPRTV	8/25/2008
Copper	Chronic	4.0E-02	mg/kg-day	1	4.0E-02	mg/kg-day	GI Tract	NA	HEAST	7/1/1997
Iron	Chronic	7.0E-01	mg/kg-day	1	7.0E-01	mg/kg-day	GI Tract	1.5	PPRTV	9/11/2006
Manganese	Chronic	1.4E-01	mg/kg-day	0.04	5.6E-03	mg/kg-day	CNS	1	IRIS	12/2/2011
Thallium	Chronic	1.0E-05	mg/kg-day	1	1.0E-05	mg/kg-day	Skin/Hair	3,000	PPRTV-S	10/8/2010
Vanadium	Chronic	7.0E-05	mg/kg-day	0.026	1.8E-06	mg/kg-day	Kidney	3,000	PPRTV	9/30/2009

[1] Oral Absorption Efficiency for Dermal from Risk Assessment Guidance for Superfund Part E, Supplemental Guidance for Dermal Risk Assessment

[2] Adjusted RfD for Dermal = Oral RfD x Oral Absorption Efficiency for Dermal.

[3] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/
Date shown for other sources is the publication date.

[4] based on chromium (VI)

Definition:

ATSDR = Agency for Toxic Substances and Disease Registry

CNS = central nervous system

GI = gastrointestinal

HEAST = Health Effect Assessment Summary Tables

IRIS = Integrated Risk Information System

mg/kg-day = milligram per kilogram per day

NA = not available

PPRTV = Provisional Peer Reviewed Toxicity Value

PPRTV-S = Screening Provisional Peer Reviewed Toxicity Value

RfD = reference dose

TABLE B-5.2a
NONCANCER TOXICITY DATA - INHALATION (CHRONIC)
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical of Potential Concern	Inhalation RfC		Primary Target Organ	Combined Uncertainty/ Modifying Factor	RfC Target Organ	
	Value	Unit			Source [1]	Date [2]
Volatile Organic Compounds						
Bromodichloromethane	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
Tetrachloroethene	4.0E-02	mg/m^3	Liver	1,000	IRIS	3/20/2012
trans-1,2-Dichloroethene	6.0E-02	mg/m^3	Lung/Liver	3,000	PPRTV	3/1/2006
Trichloroethene	2.0E-03	mg/m^3	Heart/Immunological	10 to 100	IRIS	12/2/2011
Vinyl Chloride	1.0E-01	mg/m^3	Liver	30	IRIS	12/2/2011
Semi-volatile Organic Compounds						
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA
Inorganics						
Aluminum	5.0E-03	mg/m^3	Neurological	300	PPRTV	10/23/2006
Arsenic	1.5E-05	mg/m^3	Developmental/Cardiovascular System/CNS/Lung/Skin	30	Cal/EPA	12/18/2008
Barium	5.0E-04	mg/m^3	Fetus	1,000	HEAST	7/1/1997
Chromium[3]	1.0E-04	mg/m^3	Lung	300	IRIS	12/2/2011
Cobalt	6.0E-06	mg/m^3	Respiratory System/Lung	300	PPRTV	8/25/2008
Copper	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA
Manganese	5.0E-05	mg/m^3	CNS	1,000	IRIS	12/2/2011
Thallium	NA	NA	NA	NA	NA	NA
Vanadium	1.0E-04	mg/m^3	Respiratory System	30	ATSDR	5/3/2011

[1] ATSDR chronic inhalation minimal risk level (MRL)
MRL is converted from units in ppmv to mg/m^3 using the following equation:
MRL (mg/m^3) = (ppmv)(1 kg/1000 g)(P/RT)(molecular weight)
where:
P = ambient air pressure, 1 atmosphere (atm)
R = ideal gas constant, 8.2×10^{-5} atm-m^3/mol-^{0}K
T = absolute temperature, 298.15 Kelvin (^{0}K)

[2] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/
Date shown for other sources is the publication date.

[3] based on chromium (VI) particulates

Definition:
ATSDR = Agency for Toxic Substances and Disease Registry
Cal/EPA = California Environmental Protection Agency
CNS = central nervous system
HEAST = Health Effects Assessment Summary Tables
IRIS = Integrated Risk Information System
mg/m^3 = milligram per cubic meter
NA = not available
ppmv = part per million by volume
PPRTV = Provisional Peer Reviewed Toxicity Value
RfC = reference concentration

TABLE B-5.2b
NONCANCER TOXICITY DATA - INHALATION (ACUTE)
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical of Potential Concern	Inhalation RfC		Primary Target Organ	Combined Uncertainty/ Modifying Factor	RfC Target Organ	
	Value	Unit			Source [1]	Date [2]
Volatile Organic Compounds						
Bromodichloromethane	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
Tetrachloroethene	2.0E+01	mg/m^3	CNS/Eye/Respiratory System	60	Cal/EPA	12/18/2008
trans-1,2-Dichloroethene	7.9E-01	mg/m^3	Liver	1,000	ATSDR	5/3/2011
Trichloroethene	1.1E+01	mg/m^3	CNS	30	ATSDR	5/3/2011
Vinyl Chloride	1.8E+02	mg/m^3	CNS/Eye/Respiratory System	10	Cal/EPA	12/18/2008
Semi-volatile Organic Compounds						
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA
Inorganics						
Aluminum	NA	NA	NA	NA	NA	NA
Arsenic	2.0E-04	mg/m^3	Developmental/Cardiovascular System/CNS	1,000	Cal/EPA	12/18/2008
Barium	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA
Copper	1.0E-01	mg/m^3	Respiratory System	10	Cal/EPA	12/18/2008
Iron	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA
Manganese	1.7E-04	mg/m^3	CNS	300	Cal/EPA	12/18/2008
Thallium	NA	NA	NA	NA	NA	NA
Vanadium[3]	3.0E-02	mg/m^3	Respiratory System/Eyes	10	Cal/EPA	12/18/2008

[1] ATSDR chronic inhalation minimal risk level (MRL)
MRL is converted from units in ppmv to mg/m^3 using the following equation:

$$MRL\ (mg/m^3) = (ppmv)(1\ kg/1000\ g)(P/RT)(molecular\ weight)$$

where:
P = ambient air pressure, 1 atmosphere (atm)
R = ideal gas constant, 8.2×10^{-5} atm-m^3/mol-^{0}K
T = absolute temperature, 298.15 Kelvin (^{0}K)

[2] Date shown is the publication date.

[3] based on vanadium pentoxide

Definition:
ATSDR = Agency for Toxic Substances and Disease Registry
Cal/EPA = California Environmental Protection Agency
CNS = central nervous system
mg/m^3 = milligram per cubic meter
NA = not available
ppmv = part per million by volume
RfC = reference concentration

TABLE B-6.1
CANCER TOXICITY DATA - ORAL/DERMAL
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical of Potential Concern	Oral Slope Factor		Oral Absorption Efficiency for Dermal [1]	Absorbed Slope Factor for Dermal [2]		Mutagen [3]	Weight of Evidence/ Cancer Guideline Description	Source	Date [4]
	Value	Unit		Value	Unit				
Volatile Organic Compounds									
Bromodichloromethane	6.2E-02	$(mg/kg\text{-}day)^{-1}$	1	6.2E-02	$(mg/kg\text{-}day)^{-1}$	--	B2	IRIS	12/2/2011
cis-1,2-Dichloroethene	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Dibromochloromethane	8.4E-02	$(mg/kg\text{-}day)^{-1}$	1	8.4E-02	$(mg/kg\text{-}day)^{-1}$	--	C	IRIS	12/2/2011
Tetrachloroethene	2.1E-03	$(mg/kg\text{-}day)^{-1}$	1	2.1E-03	$(mg/kg\text{-}day)^{-1}$	--	Likely to be carcinogenic to humans	IRIS	3/20/2012
trans-1,2-Dichloroethene	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Trichloroethene	4.6E-02	$(mg/kg\text{-}day)^{-1}$	1	4.6E-02	$(mg/kg\text{-}day)^{-1}$	M	carcinogenic to humans	IRIS	12/2/2011
Vinyl Chloride	7.2E-01	$(mg/kg\text{-}day)^{-1}$	1	7.2E-01	$(mg/kg\text{-}day)^{-1}$	M	A	IRIS	12/2/2011
Semi-volatile Organic Compounds									
Benzo(a)pyrene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1	7.3E+00	$(mg/kg\text{-}day)^{-1}$	M	B2	IRIS	12/2/2011
Dibenzo(a,h)anthracene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1	7.3E+00	$(mg/kg\text{-}day)^{-1}$	M	B2	EPA	7/1/1993
Inorganics									
Aluminum	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/23/2006
Arsenic	1.5E+00	$(mg/kg\text{-}day)^{-1}$	0.025	1.5E+00	$(mg/kg\text{-}day)^{-1}$	--	A	IRIS	12/2/2011
Barium	NA	NA	0.07	NA	NA	--	D	IRIS	12/2/2011
Chromium[5]	5.0E-01	$(mg/kg\text{-}day)^{-1}$	1	5.0E-01	$(mg/kg\text{-}day)^{-1}$	--	likely to be carcinogenic to humans	NJDEP	4/8/2009
Cobalt	NA	NA	1	NA	NA	--	NA	NA	NA
Copper	NA	NA	1	NA	NA	--	D	IRIS	12/2/2011
Iron	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	9/11/2006
Lead	NA	NA	1	NA	NA	--	NA	NA	NA
Manganese	NA	NA	0.04	NA	NA	--	D	IRIS	12/2/2011
Thallium	NA	NA	1	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/8/2010
Vanadium	NA	NA	0.026	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	9/30/2009

[1] Oral Absorption Efficiency for Dermal from Risk Assessment Guidance for Superfund Part E, Supplemental Guidance for Dermal Risk Assessment

[2] Oral cancer slope factor (CSF) for Dermal = Oral CSF

[3] Identified as a mutagen on the Regional Screening Level (RSL) Table, June 2011 http://www.epa.gov/region09/waste/sfund/prg/index.html

[4] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/ Date shown for other sources is the publication date.

[5] based on chromium (VI)

EPA Weight of Evidence (EPA 1986, EPA 1996):

A - Human Carcinogen
B1 - Probable human carcinogen
indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as human carcinogen

Definition:

Cal/EPA = California Environmental Protection Agency
EPA = EPA Provisional Guidance for Quantitative Assessment of Polycyclic Aromatic Hydrocarbons
IRIS = Integrated Risk Information System
M = mutagen
mg/kg-day = milligram per kilogram per day
NA = not available
NJDEP = New Jersey Department of Environmental Protection
PPRTV = Provisional Peer Reviewed Toxicity Value

EPA Weight of Evidence Narrative (EPA 2005):

Carcinogenic to human
Likely to be carcinogenic to humans
Suggestive evidence of carcinogenic potential
Inadequate information to assess carcinogenic potential
Not likely to be carcinogenic to humans

TABLE B-6.2
CANCER TOXICITY DATA - INHALATION
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Chemical of Potential Concern	Inhalation Unit Risk		Mutagen [1]	Weight of Evidence/ Cancer Guideline Description	Inhalation Unit Risk	
	Value	Unit			Source	Date [2]
Volatile Organic Compounds						
Bromodichloromethane	3.7E-05	$(\mu g/m^3)^{-1}$	--	B2	Cal/EPA	7/21/2009
cis-1,2-Dichloroethene	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Dibromochloromethane	2.7E-05	$(\mu g/m^3)^{-1}$	--	C	Cal/EPA	7/21/2009
Tetrachloroethene	2.6E-07	$(\mu g/m^3)^{-1}$	--	Likely to be carcinogenic to humans	IRIS	3/20/2012
trans-1,2-Dichloroethene	NA	NA	--	inadequate information to assess the carcinogenic potential	IRIS	12/2/2011
Trichloroethene	4.1E-06	$(\mu g/m^3)^{-1}$	M	carcinogenic to humans	IRIS	12/2/2011
Vinyl Chloride	4.4E-06	$(\mu g/m^3)^{-1}$	M	A	IRIS	12/2/2011
Semi-volatile Organic Compounds						
Benzo(a)pyrene	1.1E-03	$(\mu g/m^3)^{-1}$	M	B2	Cal/EPA	7/21/2009
Dibenzo(a,h)anthracene	1.2E-03	$(\mu g/m^3)^{-1}$	M	B2	Cal/EPA	7/21/2009
Inorganics						
Aluminum	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/23/2006
Arsenic	4.3E-03	$(\mu g/m^3)^{-1}$	--	A	IRIS	12/2/2011
Barium	NA	NA	--	D	IRIS	12/2/2011
Chromium[3]	1.2E-02	$(\mu g/m^3)^{-1}$	--	A	IRIS	12/2/2011
Cobalt	9.0E-03	$(\mu g/m^3)^{-1}$	--	likely to be carcinogenic to humans	PPRTV	8/25/2008
Copper	NA	NA	--	D	IRIS	12/2/2011
Iron	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	9/11/2006
Lead	NA	NA	--	NA	NA	NA
Manganese	NA	NA	--	D	IRIS	12/2/2011
Thallium	NA	NA	--	inadequate information to assess the carcinogenic potential	PPRTV	10/8/2010
Vanadium[4]	8.3E-03	$(\mu g/m^3)^{-1}$	--	suggestive evidence of carcinogenic potential	PPRTV	4/30/2008

[1] Idenitified as a mutagen on the Regional Screening Level (RSL) Table, June 2011, http://www.epa.gov/region09/waste/sfund/prg/index.html

[2] Date shown for IRIS is the date IRIS was searched. http://www.epa.gov/iris/ Date shown for other sources is the publication date.

[3] based on inhalation unit risk of chromium (VI)

[4] based on vanadium pentoxide

Definition:
Cal/EPA = California Environmental Protection Agency
IRIS = Integrated Risk Information System
M = mutagen
NA = not available
$\mu g/m^3$ = microgram per cubic meter
PPRTV = Provisional Peer Reviewed Toxicity Value

EPA Weight of Evidence (EPA 1986, EPA 1996):
A - Human Carcinogen
B1 - Probable human carcinogen
indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen

EPA Weight of Evidence Narrative (EPA 2005):
Carcinogenic to human
Likely to be carcinogenic to humans
Suggestive evidence of carcinogenic potential
Inadequate information to assess carcinogenic potential
Not likely to be carcinogenic to humans

IARC Classification:
2A - The agent is probably carcinogenic to humans

TABLE B-7.1
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Former Sugar Mill	Ingestion	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	2.29E-08	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	1.67E-07	6.42E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	6.29E-09	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	4.59E-08	1.76E-08	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	4.81E-03	mg/kg-day	NA	NA	NA	1.35E-02	mg/kg-day	1.00E+00	mg/kg-day	1.35E-02
				Arsenic	3.64E+00	mg/kg	1.27E-06	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.91E-06	3.56E-06	mg/kg-day	3.00E-04	mg/kg-day	1.19E-02
				Chromium	1.50E+01	mg/kg	5.25E-06	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	2.63E-06	1.47E-05	mg/kg-day	3.00E-03	mg/kg-day	4.90E-03
				Cobalt	8.79E+00	mg/kg	3.07E-06	mg/kg-day	NA	NA	NA	8.60E-06	mg/kg-day	3.00E-04	mg/kg-day	2.87E-02
				Iron	3.74E+04	mg/kg	1.31E-02	mg/kg-day	NA	NA	NA	3.66E-02	mg/kg-day	7.00E-01	mg/kg-day	5.23E-02
				Manganese	4.89E+02	mg/kg	1.71E-04	mg/kg-day	NA	NA	NA	4.78E-04	mg/kg-day	1.40E-01	mg/kg-day	3.41E-03
				Vanadium	6.37E+01	mg/kg	2.23E-05	mg/kg-day	NA	NA	NA	6.23E-05	mg/kg-day	7.00E-05	mg/kg-day	8.91E-01
			Exp. Route Total								4.74E-06					1.01E+00
Surface Soil	Surface Soil	Former Sugar Mill	Dermal Contact	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	1.97E-08	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	1.44E-07	5.51E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	5.40E-09	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	3.94E-08	1.51E-08	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	3.64E+00	mg/kg	2.52E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	3.77E-07	7.04E-07	mg/kg-day	3.00E-04	mg/kg-day	2.35E-03
				Chromium	1.50E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	8.79E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	3.74E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	4.89E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	6.37E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								5.60E-07					2.35E-03
Surface Soil	Surface Soil	Former Sugar Mill	Inhalation	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	3.93E-09	$\mu g/m^3$	1.10E-03	$(\mu g/m^3)^{-1}$	4.33E-12	1.10E-11	mg/m^3	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.08E-09	$\mu g/m^3$	1.20E-03	$(\mu g/m^3)^{-1}$	1.30E-12	3.02E-12	mg/m^3	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	8.26E-04	$\mu g/m^3$	NA	NA	NA	2.31E-06	mg/m^3	5.00E-03	mg/m^3	4.63E-04
				Arsenic	3.64E+00	mg/kg	2.18E-07	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	9.37E-10	6.10E-10	mg/m^3	1.50E-05	mg/m^3	4.07E-05
				Chromium	1.50E+01	mg/kg	9.01E-07	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	1.08E-08	2.52E-09	mg/m^3	1.00E-04	mg/m^3	2.52E-05
				Cobalt	8.79E+00	mg/kg	5.27E-07	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	4.74E-09	1.48E-09	mg/m^3	6.00E-06	mg/m^3	2.46E-04
				Iron	3.74E+04	mg/kg	2.24E-03	$\mu g/m^3$	NA	NA	NA	6.28E-06	mg/m^3	NA	NA	NA
				Manganese	4.89E+02	mg/kg	2.93E-05	$\mu g/m^3$	NA	NA	NA	8.20E-08	mg/m^3	5.00E-05	mg/m^3	1.64E-03
				Vanadium	6.37E+01	mg/kg	3.82E-06	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	3.17E-08	1.07E-08	mg/m^3	1.00E-04	mg/m^3	1.07E-04
			Exp. Route Total								4.82E-08					2.52E-03
		Exposure Point Total									5.35E-06					1.01E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.1
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	1.90E-04	mg/kg-day	NA	NA	NA	5.33E-04	mg/kg-day	2.00E-03	mg/kg-day	2.66E-01
				Tetrachloroethene	9.92E-01	µg/L	3.47E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	7.28E-09	9.71E-06	mg/kg-day	6.00E-03	mg/kg-day	1.62E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	7.98E-06	mg/kg-day	NA	NA	NA	2.23E-05	mg/kg-day	2.00E-02	mg/kg-day	1.12E-03
				Trichloroethene	5.64E-01	µg/L	1.97E-06	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	9.07E-08	5.52E-06	mg/kg-day	5.00E-04	mg/kg-day	1.10E-02
				Vinyl Chloride	7.30E-01	µg/L	2.55E-06	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.84E-06	7.14E-06	mg/kg-day	3.00E-03	mg/kg-day	2.38E-03
				Inorganics												
				Aluminum	2.04E+03	µg/L	7.12E-03	mg/kg-day	NA	NA	NA	1.99E-02	mg/kg-day	1.00E+00	mg/kg-day	1.99E-02
				Arsenic	3.80E+00	µg/L	1.33E-05	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.99E-05	3.71E-05	mg/kg-day	3.00E-04	mg/kg-day	1.24E-01
				Barium	2.04E+02	µg/L	7.11E-04	mg/kg-day	NA	NA	NA	1.99E-03	mg/kg-day	2.00E-01	mg/kg-day	9.96E-03
				Chromium	8.35E+00	µg/L	2.92E-05	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	1.46E-05	8.17E-05	mg/kg-day	3.00E-03	mg/kg-day	2.72E-02
				Cobalt	1.07E+00	µg/L	3.75E-06	mg/kg-day	NA	NA	NA	1.05E-05	mg/kg-day	3.00E-04	mg/kg-day	3.50E-02
				Copper	5.22E+01	µg/L	1.83E-04	mg/kg-day	NA	NA	NA	5.11E-04	mg/kg-day	4.00E-02	mg/kg-day	1.28E-02
				Iron	8.20E+03	µg/L	2.86E-02	mg/kg-day	NA	NA	NA	8.02E-02	mg/kg-day	7.00E-01	mg/kg-day	1.15E-01
				Manganese	4.12E+02	µg/L	1.44E-03	mg/kg-day	NA	NA	NA	4.03E-03	mg/kg-day	1.40E-01	mg/kg-day	2.88E-02
				Vanadium	1.70E+01	µg/L	5.93E-05	mg/kg-day	NA	NA	NA	1.66E-04	mg/kg-day	7.00E-05	mg/kg-day	2.37E+00
			Exp. Route Total								3.64E-05					3.03E+00
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	4.13E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	8.68E-09	1.16E-05	mg/kg-day	6.00E-03	mg/kg-day	1.93E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.42E-06	mg/kg-day	NA	NA	NA	3.96E-06	mg/kg-day	2.00E-02	mg/kg-day	1.98E-04
				Trichloroethene	5.64E-01	µg/L	6.82E-07	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	3.14E-08	1.91E-06	mg/kg-day	5.00E-04	mg/kg-day	3.82E-03
				Vinyl Chloride	7.30E-01	µg/L	2.73E-07	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.96E-07	7.63E-07	mg/kg-day	3.00E-03	mg/kg-day	2.54E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	7.44E-05	mg/kg-day	NA	NA	NA	2.08E-04	mg/kg-day	1.00E+00	mg/kg-day	2.08E-04
				Arsenic	3.80E+00	µg/L	1.38E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.08E-07	3.88E-07	mg/kg-day	3.00E-04	mg/kg-day	1.29E-03
				Barium	2.04E+02	µg/L	7.43E-06	mg/kg-day	NA	NA	NA	2.08E-05	mg/kg-day	1.40E-02	mg/kg-day	1.49E-03
				Chromium	8.35E+00	µg/L	3.05E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	1.52E-07	8.53E-07	mg/kg-day	7.50E-05	mg/kg-day	1.14E-02
				Cobalt	1.07E+00	µg/L	1.57E-08	mg/kg-day	NA	NA	NA	4.39E-08	mg/kg-day	3.00E-04	mg/kg-day	1.46E-04
				Copper	5.22E+01	µg/L	1.91E-06	mg/kg-day	NA	NA	NA	5.34E-06	mg/kg-day	4.00E-02	mg/kg-day	1.33E-04
				Iron	8.20E+03	µg/L	2.99E-04	mg/kg-day	NA	NA	NA	8.37E-04	mg/kg-day	7.00E-01	mg/kg-day	1.20E-03
				Manganese	4.12E+02	µg/L	1.50E-05	mg/kg-day	NA	NA	NA	4.21E-05	mg/kg-day	5.60E-03	mg/kg-day	7.52E-03
				Vanadium	1.70E+01	µg/L	6.19E-07	mg/kg-day	NA	NA	NA	1.73E-06	mg/kg-day	1.82E-06	mg/kg-day	9.52E-01
			Exp. Route Total								5.96E-07					9.81E-01
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	1.00E+03	$\mu g/m^3$	5.92E+00	$\mu g/m^3$	NA	NA	NA	1.66E-02	mg/m^3	NA	NA	NA
				Tetrachloroethene	1.62E+01	$\mu g/m^3$	9.58E-02	$\mu g/m^3$	2.60E-07	$(\mu g/m^3)^{-1}$	2.49E-08	2.68E-04	mg/m^3	4.00E-02	mg/m^3	6.70E-03
				trans-1,2-Dichloroethene	4.18E+01	$\mu g/m^3$	2.47E-01	$\mu g/m^3$	NA	NA	NA	6.91E-04	mg/m^3	6.00E-02	mg/m^3	1.15E-02
				Trichloroethene	9.69E+00	$\mu g/m^3$	5.73E-02	$\mu g/m^3$	4.10E-06	$(\mu g/m^3)^{-1}$	2.35E-07	1.60E-04	mg/m^3	2.00E-03	mg/m^3	8.02E-02
				Vinyl Chloride	1.40E+01	$\mu g/m^3$	8.27E-02	$\mu g/m^3$	4.40E-06	$(\mu g/m^3)^{-1}$	3.64E-07	2.32E-04	mg/m^3	1.00E-01	mg/m^3	2.32E-03
			Exp. Route Total								6.24E-07					1.01E-01
		Exposure Point Total									3.76E-05					4.11E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.2
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Former Sugar Mill	Ingestion	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	4.28E-09	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	3.13E-08	4.99E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.17E-09	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	8.57E-09	1.37E-08	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	8.99E-04	mg/kg-day	NA	NA	NA	1.05E-02	mg/kg-day	1.00E+00	mg/kg-day	1.05E-02
				Arsenic	3.64E+00	mg/kg	2.37E-07	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	3.56E-07	2.77E-06	mg/kg-day	3.00E-04	mg/kg-day	9.22E-03
				Chromium	1.50E+01	mg/kg	9.80E-07	mg/kg-day	5.00E-01	$(mg/kg-day)^{-1}$	4.90E-07	1.14E-05	mg/kg-day	3.00E-03	mg/kg-day	3.81E-03
				Cobalt	8.79E+00	mg/kg	5.73E-07	mg/kg-day	NA	NA	NA	6.69E-06	mg/kg-day	3.00E-04	mg/kg-day	2.23E-02
				Iron	3.74E+04	mg/kg	2.44E-03	mg/kg-day	NA	NA	NA	2.85E-02	mg/kg-day	7.00E-01	mg/kg-day	4.07E-02
				Manganese	4.89E+02	mg/kg	3.19E-05	mg/kg-day	NA	NA	NA	3.72E-04	mg/kg-day	1.40E-01	mg/kg-day	2.66E-03
				Vanadium	6.37E+01	mg/kg	4.16E-06	mg/kg-day	NA	NA	NA	4.85E-05	mg/kg-day	7.00E-05	mg/kg-day	6.93E-01
			Exp. Route Total								8.86E-07					7.82E-01
Surface Soil	Surface Soil	Former Sugar Mill	Dermal Contact	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	1.40E-09	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	1.02E-08	1.64E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	3.85E-10	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	2.81E-09	4.49E-09	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	3.64E+00	mg/kg	1.79E-08	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	2.69E-08	2.09E-07	mg/kg-day	3.00E-04	mg/kg-day	6.97E-04
				Chromium	1.50E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg-day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	8.79E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	3.74E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	4.89E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	6.37E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								3.99E-08					6.97E-04
Surface Soil	Surface Soil	Former Sugar Mill	Inhalation	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	9.44E-11	$\mu g/m^3$	1.10E-03	$(\mu g/m^3)^{-1}$	1.04E-13	4.83E-11	mg/m^3	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	2.59E-11	$\mu g/m^3$	1.20E-03	$(\mu g/m^3)^{-1}$	3.11E-14	1.32E-11	mg/m^3	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	1.98E-05	$\mu g/m^3$	NA	NA	NA	1.01E-05	mg/m^3	5.00E-03	mg/m^3	2.03E-03
				Arsenic	3.64E+00	mg/kg	5.23E-09	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	2.25E-11	2.67E-09	mg/m^3	2.00E-04	mg/m^3	1.34E-05
				Chromium	1.50E+01	mg/kg	2.16E-08	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	2.60E-10	1.11E-08	mg/m^3	1.00E-04	mg/m^3	1.11E-04
				Cobalt	8.79E+00	mg/kg	1.26E-08	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	1.14E-10	6.46E-09	mg/m^3	6.00E-06	mg/m^3	1.08E-03
				Iron	3.74E+04	mg/kg	5.39E-05	$\mu g/m^3$	NA	NA	NA	2.75E-05	mg/m^3	NA	NA	NA
				Manganese	4.89E+02	mg/kg	7.03E-07	$\mu g/m^3$	NA	NA	NA	3.59E-07	mg/m^3	1.70E-04	mg/m^3	2.11E-03
				Vanadium	6.37E+01	mg/kg	9.17E-08	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	7.61E-10	4.68E-08	mg/m^3	3.00E-02	mg/m^3	1.56E-06
			Exp. Route Total								1.16E-09					5.34E-03
		Exposure Point Total									9.27E-07					7.88E-01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.3
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Former Sugar Mill	Ingestion	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	4.40E-07	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	3.21E-06	8.39E-07	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.21E-07	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	8.81E-07	2.30E-07	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	2.16E-02	mg/kg-day	NA	NA	NA	1.76E-01	mg/kg-day	1.00E+00	mg/kg-day	1.76E-01
				Arsenic	3.64E+00	mg/kg	5.69E-06	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	8.54E-06	4.65E-05	mg/kg-day	3.00E-04	mg/kg-day	1.55E-01
				Chromium	1.50E+01	mg/kg	2.35E-05	mg/kg-day	5.00E-01	$(mg/kg-day)^{-1}$	1.18E-05	1.92E-04	mg/kg-day	3.00E-03	mg/kg-day	6.41E-02
				Cobalt	8.79E+00	mg/kg	1.38E-05	mg/kg-day	NA	NA	NA	1.12E-04	mg/kg-day	3.00E-04	mg/kg-day	3.75E-01
				Iron	3.74E+04	mg/kg	5.86E-02	mg/kg-day	NA	NA	NA	4.79E-01	mg/kg-day	7.00E-01	mg/kg-day	6.84E-01
				Manganese	4.89E+02	mg/kg	7.65E-04	mg/kg-day	NA	NA	NA	6.25E-03	mg/kg-day	1.40E-01	mg/kg-day	4.46E-02
				Vanadium	6.37E+01	mg/kg	9.97E-05	mg/kg-day	NA	NA	NA	8.15E-04	mg/kg-day	7.00E-05	mg/kg-day	1.16E+01
			Exp. Route Total								2.44E-05					1.31E+01
Surface Soil	Surface Soil	Former Sugar Mill	Dermal Contact	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	1.69E-07	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	1.23E-06	3.05E-07	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	4.63E-08	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	3.38E-07	8.38E-08	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	3.64E+00	mg/kg	5.39E-07	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	8.08E-07	3.90E-06	mg/kg-day	3.00E-04	mg/kg-day	1.30E-02
				Chromium	1.50E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg-day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	8.79E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	3.74E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	4.89E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	6.37E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								2.38E-06					1.30E-02
Surface Soil	Surface Soil	Former Sugar Mill	Inhalation	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	5.02E-08	$\mu g/m^3$	1.10E-03	$(\mu g/m^3)^{-1}$	5.53E-11	4.63E-11	mg/m^3	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.38E-08	$\mu g/m^3$	1.20E-03	$(\mu g/m^3)^{-1}$	1.65E-11	1.27E-11	mg/m^3	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	4.16E-03	$\mu g/m^3$	NA	NA	NA	9.71E-06	mg/m^3	5.00E-03	mg/m^3	1.94E-03
				Arsenic	3.64E+00	mg/kg	1.10E-06	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	4.72E-09	2.56E-09	mg/m^3	1.50E-05	mg/m^3	1.71E-04
				Chromium	1.50E+01	mg/kg	4.54E-06	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	5.45E-08	1.06E-08	mg/m^3	1.00E-04	mg/m^3	1.06E-04
				Cobalt	8.79E+00	mg/kg	2.66E-06	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	2.39E-08	6.20E-09	mg/m^3	6.00E-06	mg/m^3	1.03E-03
				Iron	3.74E+04	mg/kg	1.13E-02	$\mu g/m^3$	NA	NA	NA	2.64E-05	mg/m^3	NA	NA	NA
				Manganese	4.89E+02	mg/kg	1.48E-04	$\mu g/m^3$	NA	NA	NA	3.44E-07	mg/m^3	5.00E-05	mg/m^3	6.89E-03
				Vanadium	6.37E+01	mg/kg	1.93E-05	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	1.60E-07	4.49E-08	mg/m^3	1.00E-04	mg/m^3	4.49E-04
			Exp. Route Total								2.43E-07					1.06E-02
		Exposure Point Total									2.70E-05					1.32E+01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.3
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	8.10E-04	mg/kg-day	NA	NA	NA	3.48E-03	mg/kg-day	2.00E-03	mg/kg-day	1.74E+00
				Tetrachloroethene	9.92E-01	µg/L	1.48E-05	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	3.10E-08	6.34E-05	mg/kg-day	6.00E-03	mg/kg-day	1.06E-02
				trans-1,2-Dichloroethene	2.28E+00	µg/L	3.40E-05	mg/kg-day	NA	NA	NA	1.46E-04	mg/kg-day	2.00E-02	mg/kg-day	7.30E-03
				Trichloroethene	5.64E-01	µg/L	2.62E-05	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	5.54E-07	3.61E-05	mg/kg-day	5.00E-04	mg/kg-day	7.21E-02
				Vinyl Chloride	7.30E-01	µg/L	5.95E-05	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	4.29E-05	4.67E-05	mg/kg-day	3.00E-03	mg/kg-day	1.56E-02
				Inorganics												
				Aluminum	2.04E+03	µg/L	3.03E-02	mg/kg-day	NA	NA	NA	1.30E-01	mg/kg-day	1.00E+00	mg/kg-day	1.30E-01
				Arsenic	3.80E+00	µg/L	5.64E-05	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	8.47E-05	2.43E-04	mg/kg-day	3.00E-04	mg/kg-day	8.09E-01
				Barium	2.04E+02	µg/L	3.03E-03	mg/kg-day	NA	NA	NA	1.30E-02	mg/kg-day	2.00E-01	mg/kg-day	6.51E-02
				Chromium	8.35E+00	µg/L	1.24E-04	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	6.21E-05	5.34E-04	mg/kg-day	3.00E-03	mg/kg-day	1.78E-01
				Cobalt	1.07E+00	µg/L	1.60E-05	mg/kg-day	NA	NA	NA	6.87E-05	mg/kg-day	3.00E-04	mg/kg-day	2.29E-01
				Copper	5.22E+01	µg/L	7.77E-04	mg/kg-day	NA	NA	NA	3.34E-03	mg/kg-day	4.00E-02	mg/kg-day	8.35E-02
				Iron	8.20E+03	µg/L	1.22E-01	mg/kg-day	NA	NA	NA	5.24E-01	mg/kg-day	7.00E-01	mg/kg-day	7.48E-01
				Manganese	4.12E+02	µg/L	6.13E-03	mg/kg-day	NA	NA	NA	2.63E-02	mg/kg-day	1.40E-01	mg/kg-day	1.88E-01
				Vanadium	1.70E+01	µg/L	2.52E-04	mg/kg-day	NA	NA	NA	1.08E-03	mg/kg-day	7.00E-05	mg/kg-day	1.55E+01
			Exp. Route Total								1.90E-04					1.98E+01
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	8.49E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	1.78E-08	2.97E-05	mg/kg-day	6.00E-03	mg/kg-day	4.95E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	2.91E-06	mg/kg-day	NA	NA	NA	1.02E-05	mg/kg-day	2.00E-02	mg/kg-day	5.08E-04
				Trichloroethene	5.64E-01	µg/L	4.04E-06	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	8.94E-08	4.90E-06	mg/kg-day	5.00E-04	mg/kg-day	9.80E-03
				Vinyl Chloride	7.30E-01	µg/L	2.62E-06	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.89E-06	1.97E-06	mg/kg-day	3.00E-03	mg/kg-day	6.58E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	1.63E-04	mg/kg-day	NA	NA	NA	5.71E-04	mg/kg-day	1.00E+00	mg/kg-day	5.71E-04
				Arsenic	3.80E+00	µg/L	3.04E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	4.56E-07	1.06E-06	mg/kg-day	3.00E-04	mg/kg-day	3.54E-03
				Barium	2.04E+02	µg/L	1.63E-05	mg/kg-day	NA	NA	NA	5.70E-05	mg/kg-day	1.40E-02	mg/kg-day	4.07E-03
				Chromium	8.35E+00	µg/L	6.69E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	3.35E-07	2.34E-06	mg/kg-day	7.50E-05	mg/kg-day	3.12E-02
				Cobalt	1.07E+00	µg/L	3.44E-08	mg/kg-day	NA	NA	NA	1.20E-07	mg/kg-day	3.00E-04	mg/kg-day	4.01E-04
				Copper	5.22E+01	µg/L	4.19E-06	mg/kg-day	NA	NA	NA	1.46E-05	mg/kg-day	4.00E-02	mg/kg-day	3.66E-04
				Iron	8.20E+03	µg/L	6.57E-04	mg/kg-day	NA	NA	NA	2.30E-03	mg/kg-day	7.00E-01	mg/kg-day	3.28E-03
				Manganese	4.12E+02	µg/L	3.30E-05	mg/kg-day	NA	NA	NA	1.15E-04	mg/kg-day	5.60E-03	mg/kg-day	2.06E-02
				Vanadium	1.70E+01	µg/L	1.36E-06	mg/kg-day	NA	NA	NA	4.75E-06	mg/kg-day	1.82E-06	mg/kg-day	2.61E+00
			Exp. Route Total								2.79E-06					2.69E+00
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	1.41E+01	$µg/m^3$	NA	NA	NA	7.12E-02	mg/m^3	NA	NA	NA
				Tetrachloroethene	9.92E-01	µg/L	2.27E-01	$µg/m^3$	2.60E-07	$(µg/m^3)^{-1}$	5.91E-08	1.15E-03	mg/m^3	4.00E-02	mg/m^3	2.88E-02
				trans-1,2-Dichloroethene	2.28E+00	µg/L	5.86E-01	$µg/m^3$	NA	NA	NA	2.97E-03	mg/m^3	6.00E-02	mg/m^3	4.95E-02
				Trichloroethene	5.64E-01	µg/L	4.56E-01	$µg/m^3$	4.10E-06	$(µg/m^3)^{-1}$	8.78E-10	6.89E-04	mg/m^3	2.00E-03	mg/m^3	3.44E-01
				Vinyl Chloride	7.30E-01	µg/L	1.20E+00	$µg/m^3$	4.40E-06	$(µg/m^3)^{-1}$	5.26E-06	9.94E-04	mg/m^3	1.00E-01	mg/m^3	9.94E-03
			Exp. Route Total								5.32E-06					4.32E-01
		Exposure Point Total									1.98E-04					2.29E+01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$µg/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.4
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Construction Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Former Sugar Mill	Ingestion	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	4.61E-02	mg/kg	8.51E-10	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	6.21E-09	5.96E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	3.32E-10	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	2.42E-09	2.32E-08	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.73E+04	mg/kg	3.19E-04	mg/kg-day	NA	NA	NA	2.23E-02	mg/kg-day	1.00E+00	mg/kg-day	2.23E-02
				Arsenic	1.93E+00	mg/kg	3.56E-08	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	5.34E-08	2.49E-06	mg/kg-day	3.00E-04	mg/kg-day	8.30E-03
				Chromium	9.89E+00	mg/kg	1.83E-07	mg/kg-day	5.00E-01	$(mg/kg-day)^{-1}$	9.13E-08	1.28E-05	mg/kg-day	3.00E-03	mg/kg-day	4.26E-03
				Cobalt	1.09E+01	mg/kg	2.01E-07	mg/kg-day	NA	NA	NA	1.41E-05	mg/kg-day	3.00E-04	mg/kg-day	4.70E-02
				Iron	2.90E+04	mg/kg	5.36E-04	mg/kg-day	NA	NA	NA	3.75E-02	mg/kg-day	7.00E-01	mg/kg-day	5.36E-02
				Manganese	4.35E+02	mg/kg	8.03E-06	mg/kg-day	NA	NA	NA	5.62E-04	mg/kg-day	1.40E-01	mg/kg-day	4.02E-03
				Thallium	2.07E-01	mg/kg	3.82E-09	mg/kg-day	NA	NA	NA	2.67E-07	mg/kg-day	1.00E-05	mg/kg-day	2.67E-02
				Vanadium	9.62E+01	mg/kg	1.78E-06	mg/kg-day	NA	NA	NA	1.24E-04	mg/kg-day	7.00E-05	mg/kg-day	1.78E+00
			Exp. Route Total								1.53E-07					1.94E+00
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Former Sugar Mill	Dermal Contact	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	4.61E-02	mg/kg	3.32E-10	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	2.42E-09	2.32E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.30E-10	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	9.46E-10	9.07E-09	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.73E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	1.93E+00	mg/kg	3.20E-09	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	4.80E-09	2.24E-07	mg/kg-day	3.00E-04	mg/kg-day	7.47E-04
				Chromium	9.89E+00	mg/kg	NA	NA	5.00E-01	$(mg/kg-day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	1.09E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	2.90E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	4.35E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Thallium	2.07E-01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E-05	mg/kg-day	NA
				Vanadium	9.62E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								8.17E-09					7.47E-04
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Former Sugar Mill	Inhalation	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	4.61E-02	mg/kg	4.42E-11	$\mu g/m^3$	1.10E-03	$(\mu g/m^3)^{-1}$	4.87E-14	3.10E-12	mg/m^3	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.73E-11	$\mu g/m^3$	1.20E-03	$(\mu g/m^3)^{-1}$	2.07E-14	1.21E-12	mg/m^3	NA	NA	NA
				Inorganics												
				Aluminum	1.73E+04	mg/kg	1.66E-05	$\mu g/m^3$	NA	NA	NA	1.16E-06	mg/m^3	5.00E-03	mg/m^3	2.32E-04
				Arsenic	1.93E+00	mg/kg	1.85E-09	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	7.95E-12	1.29E-10	mg/m^3	1.50E-05	mg/m^3	8.63E-06
				Chromium	9.89E+00	mg/kg	9.49E-09	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	1.14E-10	6.64E-10	mg/m^3	1.00E-04	mg/m^3	6.64E-06
				Cobalt	1.09E+01	mg/kg	1.05E-08	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	9.43E-11	7.33E-10	mg/m^3	6.00E-06	mg/m^3	1.22E-04
				Iron	2.90E+04	mg/kg	2.79E-05	$\mu g/m^3$	NA	NA	NA	1.95E-06	mg/m^3	NA	NA	NA
				Manganese	4.35E+02	mg/kg	4.18E-07	$\mu g/m^3$	NA	NA	NA	2.92E-08	mg/m^3	5.00E-05	mg/m^3	5.85E-04
				Thallium	2.07E-01	mg/kg	1.99E-10	$\mu g/m^3$	NA	NA	NA	1.39E-11	mg/m^3	NA	NA	NA
				Vanadium	9.62E+01	mg/kg	9.23E-08	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	7.66E-10	6.46E-09	mg/m^3	1.00E-04	mg/m^3	6.46E-05
			Exp. Route Total								9.82E-10					1.02E-03
		Exposure Point Total									1.62E-07					1.94E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.5
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Puerto Rico Beverage	Ingestion	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	4.56E-03	mg/kg-day	NA	NA	NA	1.28E-02	mg/kg-day	1.00E+00	mg/kg-day	1.28E-02
				Arsenic	2.90E+00	mg/kg	1.01E-06	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.52E-06	2.84E-06	mg/kg-day	3.00E-04	mg/kg-day	9.46E-03
				Chromium	2.51E+01	mg/kg	8.76E-06	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	4.38E-06	2.45E-05	mg/kg-day	3.00E-03	mg/kg-day	8.18E-03
				Cobalt	6.36E+00	mg/kg	2.22E-06	mg/kg-day	NA	NA	NA	6.22E-06	mg/kg-day	3.00E-04	mg/kg-day	2.07E-02
				Iron	2.94E+04	mg/kg	1.03E-02	mg/kg-day	NA	NA	NA	2.88E-02	mg/kg-day	7.00E-01	mg/kg-day	4.11E-02
				Manganese	3.49E+02	mg/kg	1.22E-04	mg/kg-day	NA	NA	NA	3.41E-04	mg/kg-day	1.40E-01	mg/kg-day	2.44E-03
				Vanadium	5.66E+01	mg/kg	1.98E-05	mg/kg-day	NA	NA	NA	5.54E-05	mg/kg-day	7.00E-05	mg/kg-day	7.91E-01
			Exp. Route Total								5.90E-06					8.85E-01
Surface Soil	Surface Soil	Puerto Rico Beverage	Dermal Contact	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	2.90E+00	mg/kg	2.01E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	3.01E-07	5.62E-07	mg/kg-day	3.00E-04	mg/kg-day	1.87E-03
				Chromium	2.51E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	6.36E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	2.94E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	3.49E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	5.66E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								3.01E-07					1.87E-03
Surface Soil	Surface Soil	Puerto Rico Beverage	Inhalation	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	7.82E-04	$\mu g/m^3$	NA	NA	NA	2.19E-06	mg/m^3	5.00E-03	mg/m^3	4.38E-04
				Arsenic	2.90E+00	mg/kg	1.74E-07	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	7.48E-10	4.87E-10	mg/m^3	1.50E-05	mg/m^3	3.25E-05
				Chromium	2.51E+01	mg/kg	1.50E-06	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	1.80E-08	4.21E-09	mg/m^3	1.00E-04	mg/m^3	4.21E-05
				Cobalt	6.36E+00	mg/kg	3.81E-07	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	3.43E-09	1.07E-09	mg/m^3	6.00E-06	mg/m^3	1.78E-04
				Iron	2.94E+04	mg/kg	1.76E-03	$\mu g/m^3$	NA	NA	NA	4.94E-06	mg/m^3	NA	NA	NA
				Manganese	3.49E+02	mg/kg	2.09E-05	$\mu g/m^3$	NA	NA	NA	5.85E-08	mg/m^3	5.00E-05	mg/m^3	1.17E-03
				Vanadium	5.66E+01	mg/kg	3.39E-06	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	2.82E-08	9.50E-09	mg/m^3	1.00E-04	mg/m^3	9.50E-05
			Exp. Route Total								5.04E-08					1.96E-03
		Exposure Point Total									6.25E-06					8.89E-01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.5
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	1.90E-04	mg/kg-day	NA	NA	NA	5.33E-04	mg/kg-day	2.00E-03	mg/kg-day	2.66E-01
				Tetrachloroethene	9.92E-01	µg/L	3.47E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	7.28E-09	9.71E-06	mg/kg-day	6.00E-03	mg/kg-day	1.62E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	7.98E-06	mg/kg-day	NA	NA	NA	2.23E-05	mg/kg-day	2.00E-02	mg/kg-day	1.12E-03
				Trichloroethene	5.64E-01	µg/L	1.97E-06	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	9.07E-08	5.52E-06	mg/kg-day	5.00E-04	mg/kg-day	1.10E-02
				Vinyl Chloride	7.30E-01	µg/L	2.55E-06	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.84E-06	7.14E-06	mg/kg-day	3.00E-03	mg/kg-day	2.38E-03
				Inorganics												
				Aluminum	2.04E+03	µg/L	7.12E-03	mg/kg-day	NA	NA	NA	1.99E-02	mg/kg-day	1.00E+00	mg/kg-day	1.99E-02
				Arsenic	3.80E+00	µg/L	1.33E-05	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.99E-05	3.71E-05	mg/kg-day	3.00E-04	mg/kg-day	1.24E-01
				Barium	2.04E+02	µg/L	7.11E-04	mg/kg-day	NA	NA	NA	1.99E-03	mg/kg-day	2.00E-01	mg/kg-day	9.96E-03
				Chromium	8.35E+00	µg/L	2.92E-05	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	1.46E-05	8.17E-05	mg/kg-day	3.00E-03	mg/kg-day	2.72E-02
				Cobalt	1.07E+00	µg/L	3.75E-06	mg/kg-day	NA	NA	NA	1.05E-05	mg/kg-day	3.00E-04	mg/kg-day	3.50E-02
				Copper	5.22E+01	µg/L	1.83E-04	mg/kg-day	NA	NA	NA	5.11E-04	mg/kg-day	4.00E-02	mg/kg-day	1.28E-02
				Iron	8.20E+03	µg/L	2.86E-02	mg/kg-day	NA	NA	NA	8.02E-02	mg/kg-day	7.00E-01	mg/kg-day	1.15E-01
				Manganese	4.12E+02	µg/L	1.44E-03	mg/kg-day	NA	NA	NA	4.03E-03	mg/kg-day	1.40E-01	mg/kg-day	2.88E-02
				Vanadium	1.70E+01	µg/L	5.93E-05	mg/kg-day	NA	NA	NA	1.66E-04	mg/kg-day	7.00E-05	mg/kg-day	2.37E+00
			Exp. Route Total								3.64E-05					3.03E+00
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	4.13E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	8.68E-09	1.16E-05	mg/kg-day	6.00E-03	mg/kg-day	1.93E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.42E-06	mg/kg-day	NA	NA	NA	3.96E-06	mg/kg-day	2.00E-02	mg/kg-day	1.98E-04
				Trichloroethene	5.64E-01	µg/L	6.82E-07	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	3.14E-08	1.91E-06	mg/kg-day	5.00E-04	mg/kg-day	3.82E-03
				Vinyl Chloride	7.30E-01	µg/L	2.73E-07	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.96E-07	7.63E-07	mg/kg-day	3.00E-03	mg/kg-day	2.54E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	7.44E-05	mg/kg-day	NA	NA	NA	2.08E-04	mg/kg-day	1.00E+00	mg/kg-day	2.08E-04
				Arsenic	3.80E+00	µg/L	1.38E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.08E-07	3.88E-07	mg/kg-day	3.00E-04	mg/kg-day	1.29E-03
				Barium	2.04E+02	µg/L	7.43E-06	mg/kg-day	NA	NA	NA	2.08E-05	mg/kg-day	1.40E-02	mg/kg-day	1.49E-03
				Chromium	8.35E+00	µg/L	3.05E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	1.52E-07	8.53E-07	mg/kg-day	7.50E-05	mg/kg-day	1.14E-02
				Cobalt	1.07E+00	µg/L	1.57E-08	mg/kg-day	NA	NA	NA	4.39E-08	mg/kg-day	3.00E-04	mg/kg-day	1.46E-04
				Copper	5.22E+01	µg/L	1.91E-06	mg/kg-day	NA	NA	NA	5.34E-06	mg/kg-day	4.00E-02	mg/kg-day	1.33E-04
				Iron	8.20E+03	µg/L	2.99E-04	mg/kg-day	NA	NA	NA	8.37E-04	mg/kg-day	7.00E-01	mg/kg-day	1.20E-03
				Manganese	4.12E+02	µg/L	1.50E-05	mg/kg-day	NA	NA	NA	4.21E-05	mg/kg-day	5.60E-03	mg/kg-day	7.52E-03
				Vanadium	1.70E+01	µg/L	6.19E-07	mg/kg-day	NA	NA	NA	1.73E-06	mg/kg-day	1.82E-06	mg/kg-day	9.52E-01
			Exp. Route Total								5.96E-07					9.81E-01
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	1.00E+03	$\mu g/m^3$	5.92E+00	$\mu g/m^3$	NA	NA	NA	1.66E-02	mg/m^3	NA	NA	NA
				Tetrachloroethene	1.62E+01	$\mu g/m^3$	9.58E-02	$\mu g/m^3$	2.60E-07	$(\mu g/m^3)^{-1}$	2.49E-08	2.68E-04	mg/m^3	4.00E-02	mg/m^3	6.70E-03
				trans-1,2-Dichloroethene	4.18E+01	$\mu g/m^3$	2.47E-01	$\mu g/m^3$	NA	NA	NA	6.91E-04	mg/m^3	6.00E-02	mg/m^3	1.15E-02
				Trichloroethene	9.69E+00	$\mu g/m^3$	5.73E-02	$\mu g/m^3$	4.10E-06	$(\mu g/m^3)^{-1}$	2.35E-07	1.60E-04	mg/m^3	2.00E-03	mg/m^3	8.02E-02
				Vinyl Chloride	1.40E+01	$\mu g/m^3$	8.27E-02	$\mu g/m^3$	4.40E-06	$(\mu g/m^3)^{-1}$	3.64E-07	2.32E-04	mg/m^3	1.00E-01	mg/m^3	2.32E-03
			Exp. Route Total								6.24E-07					1.01E-01
		Exposure Point Total									3.76E-05					4.11E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.6
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Puerto Rico Beverage	Ingestion	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	8.51E-04	mg/kg-day	NA	NA	NA	9.92E-03	mg/kg-day	1.00E+00	mg/kg-day	9.92E-03
				Arsenic	2.90E+00	mg/kg	1.89E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.84E-07	2.21E-06	mg/kg-day	3.00E-04	mg/kg-day	7.36E-03
				Chromium	2.51E+01	mg/kg	1.64E-06	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	8.18E-07	1.91E-05	mg/kg-day	3.00E-03	mg/kg-day	6.36E-03
				Cobalt	6.36E+00	mg/kg	4.15E-07	mg/kg-day	NA	NA	NA	4.84E-06	mg/kg-day	3.00E-04	mg/kg-day	1.61E-02
				Iron	2.94E+04	mg/kg	1.92E-03	mg/kg-day	NA	NA	NA	2.24E-02	mg/kg-day	7.00E-01	mg/kg-day	3.20E-02
				Manganese	3.49E+02	mg/kg	2.27E-05	mg/kg-day	NA	NA	NA	2.65E-04	mg/kg-day	1.40E-01	mg/kg-day	1.90E-03
				Vanadium	5.66E+01	mg/kg	3.69E-06	mg/kg-day	NA	NA	NA	4.31E-05	mg/kg-day	7.00E-05	mg/kg-day	6.15E-01
			Exp. Route Total								1.10E-06					6.89E-01
Surface Soil	Surface Soil	Puerto Rico Beverage	Dermal Contact	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	2.90E+00	mg/kg	1.43E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.15E-08	1.67E-07	mg/kg-day	3.00E-04	mg/kg-day	5.56E-04
				Chromium	2.51E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	6.36E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	2.94E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	3.49E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	5.66E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								2.15E-08					5.56E-04
Surface Soil	Surface Soil	Puerto Rico Beverage	Inhalation	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	1.88E-05	$\mu g/m^3$	NA	NA	NA	9.59E-06	mg/m^3	5.00E-03	mg/m^3	1.92E-03
				Arsenic	2.90E+00	mg/kg	4.17E-09	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	1.79E-11	2.13E-09	mg/m^3	2.00E-04	mg/m^3	1.07E-05
				Chromium	2.51E+01	mg/kg	3.61E-08	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	4.33E-10	1.84E-08	mg/m^3	1.00E-04	mg/m^3	1.84E-04
				Cobalt	6.36E+00	mg/kg	9.15E-09	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	8.23E-11	4.67E-09	mg/m^3	6.00E-06	mg/m^3	7.79E-04
				Iron	2.94E+04	mg/kg	4.24E-05	$\mu g/m^3$	NA	NA	NA	2.16E-05	mg/m^3	NA	NA	NA
				Manganese	3.49E+02	mg/kg	5.02E-07	$\mu g/m^3$	NA	NA	NA	2.56E-07	mg/m^3	1.70E-04	mg/m^3	1.51E-03
				Vanadium	5.66E+01	mg/kg	8.14E-08	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	6.76E-10	4.16E-08	mg/m^3	3.00E-02	mg/m^3	1.39E-06
			Exp. Route Total								1.21E-09					4.40E-03
		Exposure Point Total									1.12E-06					6.94E-01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.7
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Puerto Rico Beverage	Ingestion	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	2.04E-02	mg/kg-day	NA	NA	NA	1.67E-01	mg/kg-day	1.00E+00	mg/kg-day	1.67E-01
				Arsenic	2.90E+00	mg/kg	4.54E-06	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	6.81E-06	3.71E-05	mg/kg-day	3.00E-04	mg/kg-day	1.24E-01
				Chromium	2.51E+01	mg/kg	3.92E-05	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	1.96E-05	3.21E-04	mg/kg-day	3.00E-03	mg/kg-day	1.07E-01
				Cobalt	6.36E+00	mg/kg	9.95E-06	mg/kg-day	NA	NA	NA	8.13E-05	mg/kg-day	3.00E-04	mg/kg-day	2.71E-01
				Iron	2.94E+04	mg/kg	4.61E-02	mg/kg-day	NA	NA	NA	3.76E-01	mg/kg-day	7.00E-01	mg/kg-day	5.38E-01
				Manganese	3.49E+02	mg/kg	5.46E-04	mg/kg-day	NA	NA	NA	4.46E-03	mg/kg-day	1.40E-01	mg/kg-day	3.18E-02
				Vanadium	5.66E+01	mg/kg	8.86E-05	mg/kg-day	NA	NA	NA	7.23E-04	mg/kg-day	7.00E-05	mg/kg-day	1.03E+01
			Exp. Route Total								2.64E-05					1.16E+01
Surface Soil	Surface Soil	Puerto Rico Beverage	Dermal Contact	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	2.90E+00	mg/kg	4.30E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	6.45E-07	3.11E-06	mg/kg-day	3.00E-04	mg/kg-day	1.04E-02
				Chromium	2.51E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	6.36E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	2.94E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	3.49E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	5.66E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								6.45E-07					1.04E-02
Surface Soil	Surface Soil	Puerto Rico Beverage	Inhalation	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	3.94E-03	$\mu g/m^3$	NA	NA	NA	9.19E-06	mg/m^3	5.00E-03	mg/m^3	1.84E-03
				Arsenic	2.90E+00	mg/kg	8.76E-07	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	3.77E-09	2.04E-09	mg/m^3	1.50E-05	mg/m^3	1.36E-04
				Chromium	2.51E+01	mg/kg	7.58E-06	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	9.09E-08	1.77E-08	mg/m^3	1.00E-04	mg/m^3	1.77E-04
				Cobalt	6.36E+00	mg/kg	1.92E-06	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	1.73E-08	4.48E-09	mg/m^3	6.00E-06	mg/m^3	7.47E-04
				Iron	2.94E+04	mg/kg	8.90E-03	$\mu g/m^3$	NA	NA	NA	2.08E-05	mg/m^3	NA	NA	NA
				Manganese	3.49E+02	mg/kg	1.05E-04	$\mu g/m^3$	NA	NA	NA	2.46E-07	mg/m^3	5.00E-05	mg/m^3	4.92E-03
				Vanadium	5.66E+01	mg/kg	1.71E-05	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	1.42E-07	3.99E-08	mg/m^3	1.00E-04	mg/m^3	3.99E-04
			Exp. Route Total								2.54E-07					8.22E-03
		Exposure Point Total									2.73E-05					1.16E+01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.7
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	8.10E-04	mg/kg-day	NA	NA	NA	3.48E-03	mg/kg-day	2.00E-03	mg/kg-day	1.74E+00
				Tetrachloroethene	9.92E-01	µg/L	1.48E-05	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	3.10E-08	6.34E-05	mg/kg-day	6.00E-03	mg/kg-day	1.06E-02
				trans-1,2-Dichloroethene	2.28E+00	µg/L	3.40E-05	mg/kg-day	NA	NA	NA	1.46E-04	mg/kg-day	2.00E-02	mg/kg-day	7.30E-03
				Trichloroethene	5.64E-01	µg/L	2.62E-05	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	5.54E-07	3.61E-05	mg/kg-day	5.00E-04	mg/kg-day	7.21E-02
				Vinyl Chloride	7.30E-01	µg/L	5.95E-05	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	4.29E-05	4.67E-05	mg/kg-day	3.00E-03	mg/kg-day	1.56E-02
				Inorganics												
				Aluminum	2.04E+03	µg/L	3.03E-02	mg/kg-day	NA	NA	NA	1.30E-01	mg/kg-day	1.00E+00	mg/kg-day	1.30E-01
				Arsenic	3.80E+00	µg/L	5.64E-05	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	8.47E-05	2.43E-04	mg/kg-day	3.00E-04	mg/kg-day	8.09E-01
				Barium	2.04E+02	µg/L	3.03E-03	mg/kg-day	NA	NA	NA	1.30E-02	mg/kg-day	2.00E-01	mg/kg-day	6.51E-02
				Chromium	8.35E+00	µg/L	1.24E-04	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	6.21E-05	5.34E-04	mg/kg-day	3.00E-03	mg/kg-day	1.78E-01
				Cobalt	1.07E+00	µg/L	1.60E-05	mg/kg-day	NA	NA	NA	6.87E-05	mg/kg-day	3.00E-04	mg/kg-day	2.29E-01
				Copper	5.22E+01	µg/L	7.77E-04	mg/kg-day	NA	NA	NA	3.34E-03	mg/kg-day	4.00E-02	mg/kg-day	8.35E-02
				Iron	8.20E+03	µg/L	1.22E-01	mg/kg-day	NA	NA	NA	5.24E-01	mg/kg-day	7.00E-01	mg/kg-day	7.48E-01
				Manganese	4.12E+02	µg/L	6.13E-03	mg/kg-day	NA	NA	NA	2.63E-02	mg/kg-day	1.40E-01	mg/kg-day	1.88E-01
				Vanadium	1.70E+01	µg/L	2.52E-04	mg/kg-day	NA	NA	NA	1.08E-03	mg/kg-day	7.00E-05	mg/kg-day	1.55E+01
			Exp. Route Total								1.90E-04					1.98E+01
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	8.49E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	1.78E-08	2.97E-05	mg/kg-day	6.00E-03	mg/kg-day	4.95E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	2.91E-06	mg/kg-day	NA	NA	NA	1.02E-05	mg/kg-day	2.00E-02	mg/kg-day	5.08E-04
				Trichloroethene	5.64E-01	µg/L	4.04E-06	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	8.94E-08	4.90E-06	mg/kg-day	5.00E-04	mg/kg-day	9.80E-03
				Vinyl Chloride	7.30E-01	µg/L	2.62E-06	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.89E-06	1.97E-06	mg/kg-day	3.00E-03	mg/kg-day	6.58E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	1.63E-04	mg/kg-day	NA	NA	NA	5.71E-04	mg/kg-day	1.00E+00	mg/kg-day	5.71E-04
				Arsenic	3.80E+00	µg/L	3.04E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	4.56E-07	1.06E-06	mg/kg-day	3.00E-04	mg/kg-day	3.54E-03
				Barium	2.04E+02	µg/L	1.63E-05	mg/kg-day	NA	NA	NA	5.70E-05	mg/kg-day	1.40E-02	mg/kg-day	4.07E-03
				Chromium	8.35E+00	µg/L	6.69E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	3.35E-07	2.34E-06	mg/kg-day	7.50E-05	mg/kg-day	3.12E-02
				Cobalt	1.07E+00	µg/L	3.44E-08	mg/kg-day	NA	NA	NA	1.20E-07	mg/kg-day	3.00E-04	mg/kg-day	4.01E-04
				Copper	5.22E+01	µg/L	4.19E-06	mg/kg-day	NA	NA	NA	1.46E-05	mg/kg-day	4.00E-02	mg/kg-day	3.66E-04
				Iron	8.20E+03	µg/L	6.57E-04	mg/kg-day	NA	NA	NA	2.30E-03	mg/kg-day	7.00E-01	mg/kg-day	3.28E-03
				Manganese	4.12E+02	µg/L	3.30E-05	mg/kg-day	NA	NA	NA	1.15E-04	mg/kg-day	5.60E-03	mg/kg-day	2.06E-02
				Vanadium	1.70E+01	µg/L	1.36E-06	mg/kg-day	NA	NA	NA	4.75E-06	mg/kg-day	1.82E-06	mg/kg-day	2.61E+00
			Exp. Route Total								2.79E-06					2.69E+00
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	1.41E+01	$µg/m^3$	NA	NA	NA	7.12E-02	mg/m^3	NA	NA	NA
				Tetrachloroethene	9.92E-01	µg/L	2.27E-01	$µg/m^3$	2.60E-07	$(µg/m^3)^{-1}$	5.91E-08	1.15E-03	mg/m^3	4.00E-02	mg/m^3	2.88E-02
				trans-1,2-Dichloroethene	2.28E+00	µg/L	5.86E-01	$µg/m^3$	NA	NA	NA	2.97E-03	mg/m^3	6.00E-02	mg/m^3	4.95E-02
				Trichloroethene	5.64E-01	µg/L	4.56E-01	$µg/m^3$	4.10E-06	$(µg/m^3)^{-1}$	8.78E-10	6.89E-04	mg/m^3	2.00E-03	mg/m^3	3.44E-01
				Vinyl Chloride	7.30E-01	µg/L	1.20E+00	$µg/m^3$	4.40E-06	$(µg/m^3)^{-1}$	5.26E-06	9.94E-04	mg/m^3	1.00E-01	mg/m^3	9.94E-03
			Exp. Route Total								5.32E-06					4.32E-01
		Exposure Point Total									1.98E-04					2.29E+01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$µg/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.8
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Construction Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Puerto Rico Beverage	Ingestion	**Inorganics**												
				Aluminum	1.64E+04	mg/kg	3.02E-04	mg/kg-day	NA	NA	NA	2.12E-02	mg/kg-day	1.00E+00	mg/kg-day	2.12E-02
				Arsenic	7.20E-01	mg/kg	1.33E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.99E-08	9.30E-07	mg/kg-day	3.00E-04	mg/kg-day	3.10E-03
				Chromium	5.81E+00	mg/kg	1.07E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	5.36E-08	7.50E-06	mg/kg-day	3.00E-03	mg/kg-day	2.50E-03
				Cobalt	8.12E+00	mg/kg	1.50E-07	mg/kg-day	NA	NA	NA	1.05E-05	mg/kg-day	3.00E-04	mg/kg-day	3.50E-02
				Iron	2.80E+04	mg/kg	5.16E-04	mg/kg-day	NA	NA	NA	3.61E-02	mg/kg-day	7.00E-01	mg/kg-day	5.16E-02
				Manganese	3.27E+02	mg/kg	6.03E-06	mg/kg-day	NA	NA	NA	4.22E-04	mg/kg-day	1.40E-01	mg/kg-day	3.02E-03
				Vanadium	8.55E+01	mg/kg	1.58E-06	mg/kg-day	NA	NA	NA	1.10E-04	mg/kg-day	7.00E-05	mg/kg-day	1.58E+00
			Exp. Route Total								7.35E-08					1.69E+00
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Puerto Rico Beverage	Dermal Contact	**Inorganics**												
				Aluminum	1.64E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	7.20E-01	mg/kg	1.20E-09	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.79E-09	8.37E-08	mg/kg-day	3.00E-04	mg/kg-day	2.79E-04
				Chromium	5.81E+00	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	8.12E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	2.80E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	3.27E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	8.55E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								1.79E-09					2.79E-04
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Puerto Rico Beverage	Inhalation	**Inorganics**												
				Aluminum	1.64E+04	mg/kg	1.57E-05	$\mu g/m^3$	NA	NA	NA	1.10E-06	mg/m^3	5.00E-03	mg/m^3	2.20E-04
				Arsenic	7.20E-01	mg/kg	6.91E-10	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	2.97E-12	4.83E-11	mg/m^3	1.50E-05	mg/m^3	3.22E-06
				Chromium	5.81E+00	mg/kg	5.57E-09	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	6.68E-11	3.90E-10	mg/m^3	1.00E-04	mg/m^3	3.90E-06
				Cobalt	8.12E+00	mg/kg	7.79E-09	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	7.01E-11	5.45E-10	mg/m^3	6.00E-06	mg/m^3	9.09E-05
				Iron	2.80E+04	mg/kg	2.68E-05	$\mu g/m^3$	NA	NA	NA	1.88E-06	mg/m^3	NA	NA	NA
				Manganese	3.27E+02	mg/kg	3.14E-07	$\mu g/m^3$	NA	NA	NA	2.20E-08	mg/m^3	5.00E-05	mg/m^3	4.39E-04
				Vanadium	8.55E+01	mg/kg	8.20E-08	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	6.80E-10	5.74E-09	mg/m^3	1.00E-04	mg/m^3	5.74E-05
			Exp. Route Total								8.20E-10					8.14E-04
		Exposure Point Total									7.61E-08					1.69E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-7.9
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Recreational Users
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Sediment	Sediment	Maunabo River	Ingestion	**Inorganics**												
				Arsenic	2.70E+00	mg/kg	3.08E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	4.62E-07	3.60E-06	mg/kg-day	3.00E-04	mg/kg-day	1.20E-02
				Chromium	4.69E+00	mg/kg	5.36E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	2.68E-07	6.25E-06	mg/kg-day	3.00E-03	mg/kg-day	2.08E-03
				Cobalt	5.29E+00	mg/kg	6.03E-07	mg/kg-day	NA	NA	NA	7.04E-06	mg/kg-day	3.00E-04	mg/kg-day	2.35E-02
				Iron	1.05E+04	mg/kg	1.20E-03	mg/kg-day	NA	NA	NA	1.40E-02	mg/kg-day	7.00E-01	mg/kg-day	2.00E-02
				Manganese	3.10E+02	mg/kg	3.54E-05	mg/kg-day	NA	NA	NA	4.13E-04	mg/kg-day	1.40E-01	mg/kg-day	2.95E-03
				Vanadium	5.41E+01	mg/kg	6.18E-06	mg/kg-day	NA	NA	NA	7.21E-05	mg/kg-day	7.00E-05	mg/kg-day	1.03E+00
			Exp. Route Total								7.30E-07					1.09E+00
Sediment	Sediment	Maunabo River	Dermal Contact	**Inorganics**												
				Arsenic	2.70E+00	mg/kg	8.14E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.22E-07	9.49E-07	mg/kg-day	3.00E-04	mg/kg-day	3.16E-03
				Chromium	4.69E+00	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	5.29E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	1.05E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	3.10E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	5.41E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								1.22E-07					3.16E-03
		Exposure Point Total									8.52E-07					1.09E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day

TABLE B-7.9
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Recreational Users
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Water	Surface Water	Maunabo River	Ingestion	**Volatile Organic Compounds**												
				Bromodichloromethane	1.00E+00	µg/L	5.71E-08	mg/kg-day	6.20E-02	$(mg/kg\text{-}day)^{-1}$	3.54E-09	6.66E-07	mg/kg-day	2.00E-02	mg/kg-day	3.33E-05
				Dibromochloromethane	1.30E+00	µg/L	7.42E-08	mg/kg-day	8.40E-02	$(mg/kg\text{-}day)^{-1}$	6.23E-09	8.66E-07	mg/kg-day	2.00E-02	mg/kg-day	4.33E-05
			Exp. Route Total								9.77E-09					7.66E-05
Surface Water	Surface Water	Maunabo River	Dermal Contact	**Volatile Organic Compounds**												
				Bromodichloromethane	1.00E+00	µg/L	1.50E-07	mg/kg-day	6.20E-02	$(mg/kg\text{-}day)^{-1}$	9.29E-09	1.75E-06	mg/kg-day	2.00E-02	mg/kg-day	8.74E-05
				Dibromochloromethane	1.30E+00	µg/L	1.81E-07	mg/kg-day	8.40E-02	$(mg/kg\text{-}day)^{-1}$	1.52E-08	2.11E-06	mg/kg-day	2.00E-02	mg/kg-day	1.06E-04
			Exp. Route Total								2.45E-08					1.93E-04
		Exposure Point Total									3.43E-08					2.69E-04

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day

TABLE B-7.10
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Non-Cancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Water	Surface Water	Tap Water	Ingestion	**Volatile Organic Compounds**												
				Bromodichloromethane	1.00E+00	µg/L	1.49E-05	mg/kg-day	6.20E-02	$(mg/kg\text{-}day)^{-1}$	9.22E-07	6.39E-05	mg/kg-day	2.00E-02	mg/kg-day	3.20E-03
				Dibromochloromethane	1.30E+00	µg/L	1.93E-05	mg/kg-day	8.40E-02	$(mg/kg\text{-}day)^{-1}$	1.62E-06	8.31E-05	mg/kg-day	2.00E-02	mg/kg-day	4.16E-03
			Exp. Route Total								2.55E-06					7.35E-03
Surface Water	Surface Water	Tap Water	Dermal Contact	**Volatile Organic Compounds**												
				Bromodichloromethane	1.00E+00	µg/L	NA	NA	6.20E-02	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	2.00E-02	mg/kg-day	NA
				Dibromochloromethane	1.30E+00	µg/L	NA	NA	8.40E-02	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	2.00E-02	mg/kg-day	NA
			Exp. Route Total								--					--
Surface Water	Surface Water	Tap Water	Inhalation	**Volatile Organic Compounds**												
				Bromodichloromethane	1.00E+00	µg/L	2.49E-01	$µg/m^3$	3.70E-05	$(µg/m^3)^{-1}$	9.21E-06	1.26E-03	mg/m^3	NA	NA	NA
				Dibromochloromethane	1.30E+00	µg/L	3.22E-01	$µg/m^3$	2.70E-05	$(µg/m^3)^{-1}$	8.69E-06	1.63E-03	mg/m^3	NA	NA	NA
			Exp. Route Total								1.79E-05					--
		Exposure Point Total									2.04E-05					7.35E-03

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$µg/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE B-8
CALCULATION OF RADIATION CANCER RISKS
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	NA
Receptor Population:	NA
Receptor Age:	NA

Medium	Exposure Medium	Exposure Point	Exposure Route	Radionuclide of Potential Concern	Exposure Point Concentration		Risk Calculation Approach	Cancer Risk Calculation				
								Intake/Activity		Cancer Slope Factor		
					Value	Unit		Value	Unit	Value	Unit	Cancer Risk
			Exp. Route Total									
		Exposure Point Total										
											Total of Receptor Risks Across All Media	

NOT APPLICABLE TO THIS SITE

There are no radionucleotides in this risk assessment. As a result, this table is blank

TABLE B-9.1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	2E-07	1E-07	4E-12	3E-07	NA	NA	NA	NA	NA
			Dibenzo(a,h)anthracene	5E-08	4E-08	1E-12	9E-08	NA	NA	NA	NA	NA
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	1E-02	NA	5E-04	1E-02
			Arsenic	2E-06	4E-07	9E-10	2E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-02	2E-03	4E-05	1E-02
			Chromium	3E-06	NA	1E-08	3E-06	Lung	5E-03	NA	3E-05	5E-03
			Cobalt	NA	NA	5E-09	5E-09	Thyroid/Respiratory System/Lung	3E-02	NA	2E-04	3E-02
			Iron	NA	NA	NA	NA	GI Tract	5E-02	NA	NA	5E-02
			Manganese	NA	NA	NA	NA	CNS	3E-03	NA	2E-03	5E-03
			Vanadium	NA	NA	3E-08	3E-08	Kidney/Respiratory System	9E-01	NA	1E-04	9E-01
			Chemical Total	5E-06	6E-07	5E-08	5E-06	Chemical Total	1E+00	2E-03	3E-03	1E+00
		Exposure Point Total					5E-06					1E+00
	Exposure Medium Total						5E-06					1E+00
Medium Total							5E-06					1E+00

TABLE B-9.1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	3E-01	NA	NA	3E-01
			Tetrachloroethene	7E-09	9E-09	2E-08	4E-08	Liver	2E-03	2E-03	7E-03	1E-02
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	1E-03	2E-04	1E-02	1E-02
			Trichloroethene	9E-08	3E-08	2E-07	4E-07	Heart/ Immunogical/ Developmental/Kidney	1E-02	4E-03	8E-02	1E-01
			Vinyl Chloride	2E-06	2E-07	4E-07	2E-06	Liver	2E-03	3E-04	2E-03	5E-03
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	2E-02	2E-04	NA	2E-02
			Arsenic	2E-05	2E-07	NA	2E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	1E-03	NA	1E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	1E-02	1E-03	NA	1E-02
			Chromium	1E-05	2E-07	NA	1E-05	Lung	3E-02	1E-02	NA	4E-02
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	4E-02	1E-04	NA	4E-02
			Copper	NA	NA	NA	NA	GI Tract	1E-02	1E-04	NA	1E-02
			Iron	NA	NA	NA	NA	GI Tract	1E-01	1E-03	NA	1E-01
			Manganese	NA	NA	NA	NA	CNS	3E-02	8E-03	NA	4E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	1E+00	NA	3E+00
			Chemical Total	4E-05	6E-07	6E-07	4E-05	Chemical Total	3E+00	1E+00	1E-01	4E+00
		Exposure Point Total					4E-05					4E+00
	Exposure Medium Total						4E-05					4E+00
Medium Total							4E-05					4E+00
Receptor Total							4E-05					5E+00

Total Excess Cancer Risk Across All Media	4E-05	Total Hazard Index Across All Media	5

Blood HI Across All Media =	0.01
Liver HI Across All Media =	0.03
Kidney HI Across All Media =	5
CNS HI Across All Media =	0.2
Development HI Across All Media =	0.2
Respiratory System HI Across All Media =	4
Lung HI Across All Media =	0.3
Cardiovascular System HI Across All Media =	0.1
Skin HI Across All Media =	0.1
Heart HI Across All Media =	0.1
GI Tract HI Across All Media =	0.2
Fetus HI Across All Media =	0.01

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	3E-08	1E-08	1E-13	4E-08	NA	NA	NA	NA	NA
			Dibenzo(a,h)anthracene	9E-09	3E-09	3E-14	1E-08	NA	NA	NA	NA	NA
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	1E-02	NA	2E-03	1E-02
			Arsenic	4E-07	3E-08	2E-11	4E-07	Skin/Developmental/ Cardiovascular System/CNS	9E-03	7E-04	1E-05	1E-02
			Chromium	5E-07	NA	3E-10	5E-07	None reported	4E-03	NA	1E-04	4E-03
			Cobalt	NA	NA	1E-10	1E-10	Thyroid	2E-02	NA	1E-03	2E-02
			Iron	NA	NA	NA	NA	GI Tract	4E-02	NA	NA	4E-02
			Manganese	NA	NA	NA	NA	CNS	3E-03	NA	2E-03	5E-03
			Vanadium	NA	NA	8E-10	8E-10	Kidney/Respiratory System/Eyes	7E-01	NA	2E-06	7E-01
			Chemical Total	9E-07	4E-08	1E-09	9E-07	Chemical Total	8E-01	7E-04	5E-03	8E-01
		Exposure Point Total					9E-07					8E-01
	Exposure Medium Total						9E-07					8E-01
Medium Total							9E-07					8E-01
Receptor Total							9E-07					8E-01

Total Excess Cancer Risk Across All Media	9E-07
Total Hazard Index Across All Media	0.8
Kidney HI Across All Media =	0.7
CNS HI Across All Media =	0.01
Development HI Across All Media =	<0.01
Respiratory System HI Across All Media =	0.7
Eyes HI Across All Media =	0.7
Cardiovascular System HI Across All Media =	<0.01
Skin HI Across All Media =	<0.01
GI Tract HI Across All Media =	0.04

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	3E-06	1E-06	6E-11	4E-06	NA	NA	NA	NA	NA
			Dibenzo(a,h)anthracene	9E-07	3E-07	2E-11	1E-06	NA	NA	NA	NA	NA
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	2E-01	NA	2E-03	2E-01
			Arsenic	9E-06	8E-07	5E-09	9E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	2E-01	1E-02	2E-04	2E-01
			Chromium	1E-05	NA	5E-08	1E-05	Lung	6E-02	NA	1E-04	6E-02
			Cobalt	NA	NA	2E-08	2E-08	Thyroid/Respiratory System/Lung	4E-01	NA	1E-03	4E-01
			Iron	NA	NA	NA	NA	GI Tract	7E-01	NA	NA	7E-01
			Manganese	NA	NA	NA	NA	CNS	4E-02	NA	7E-03	5E-02
			Vanadium	NA	NA	2E-07	2E-07	Kidney/Respiratory System	1E+01	NA	4E-04	1E+01
			Chemical Total	2E-05	2E-06	2E-07	3E-05	Chemical Total	1E+01	1E-02	1E-02	1E+01
		Exposure Point Total					3E-05					1E+01
	Exposure Medium Total						3E-05					1E+01
Medium Total							3E-05					1E+01

TABLE B-9.3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	2E+00	NA	NA	2E+00
			Tetrachloroethene	3E-08	2E-08	6E-08	1E-07	Liver	1E-02	5E-03	3E-02	4E-02
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	7E-03	5E-04	5E-02	6E-02
			Trichloroethene	6E-07	9E-08	9E-10	6E-07	Heart/ Immunogical/ Developmental/Kidney	7E-02	1E-02	3E-01	4E-01
			Vinyl Chloride	4E-05	2E-06	5E-06	5E-05	Liver	2E-02	7E-04	1E-02	3E-02
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	1E-01	6E-04	NA	1E-01
			Arsenic	8E-05	5E-07	NA	9E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	8E-01	4E-03	NA	8E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	7E-02	4E-03	NA	7E-02
			Chromium	6E-05	3E-07	NA	6E-05	Lung	2E-01	3E-02	NA	2E-01
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	2E-01	4E-04	NA	2E-01
			Copper	NA	NA	NA	NA	GI Tract	8E-02	4E-04	NA	8E-02
			Iron	NA	NA	NA	NA	GI Tract	7E-01	3E-03	NA	8E-01
			Manganese	NA	NA	NA	NA	CNS	2E-01	2E-02	NA	2E-01
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+01	3E+00	NA	2E+01
			Chemical Total	2E-04	3E-06	5E-06	2E-04	Chemical Total	2E+01	3E+00	4E-01	2E+01
		Exposure Point Total					2E-04					2E+01
	Exposure Medium Total						2E-04					2E+01
Medium Total							2E-04					2E+01
Receptor Total							2E-04					4E+01

Total Excess Cancer Risk Across All Media	2E-04
Total Hazard Index Across All Media	36

Blood HI Across All Media =	0.06
Liver HI Across All Media =	0.1
Kidney HI Across All Media =	32
CNS HI Across All Media =	1
Development HI Across All Media =	1
Respiratory System HI Across All Media =	30
Lung HI Across All Media =	2
Cardiovascular System HI Across All Media =	1
Skin HI Across All Media =	1
Heart HI Across All Media =	0.4
GI Tract HI Across All Media =	2
Fetus HI Across All Media =	0.07

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Construction Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	6E-09	2E-09	5E-14	9E-09	NA	NA	NA	NA	NA
			Dibenzo(a,h)anthracene	2E-09	9E-10	2E-14	3E-09	NA	NA	NA	NA	NA
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	2E-02	NA	2E-04	2E-02
			Arsenic	5E-08	5E-09	8E-12	6E-08	Skin/Developmental/ Cardiovascular System/CNS/Lung	8E-03	7E-04	9E-06	9E-03
			Chromium	9E-08	NA	1E-10	9E-08	Lung	4E-03	NA	7E-06	4E-03
			Cobalt	NA	NA	9E-11	9E-11	Thyroid/Respiratory System/Lung	5E-02	NA	1E-04	5E-02
			Iron	NA	NA	NA	NA	GI Tract	5E-02	NA	NA	5E-02
			Manganese	NA	NA	NA	NA	CNS	4E-03	NA	6E-04	5E-03
			Thallium	NA	NA	NA	NA	Skin/Hair	3E-02	NA	NA	3E-02
			Vanadium	NA	NA	8E-10	8E-10	Kidney/Respiratory System	2E+00	NA	6E-05	2E+00
			Chemical Total	2E-07	8E-09	1E-09	2E-07	Chemical Total	2E+00	7E-04	1E-03	2E+00
		Exposure Point Total					2E-07					2E+00
	Exposure Medium Total						2E-07					2E+00
Medium Total							2E-07					2E+00
Receptor Total							2E-07					2E+00

Total Excess Cancer Risk Across All Media	2E-07
Total Hazard Index Across All Media	2

Kidney HI Across All Media =	2
CNS HI Across All Media =	0.01
Development HI Across All Media =	<0.01
Respiratory System HI Across All Media =	2
Lung HI Across All Media =	0.06
Cardiovascular System HI Across All Media =	<0.01
Skin HI Across All Media =	0.04
GI Tract HI Across All Media =	0.05
Hair HI Across All Media =	0.03

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.5
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Aluminum	NA	NA	NA	NA	Neurological	1E-02	NA	4E-04	1E-02
			Arsenic	2E-06	3E-07	7E-10	2E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	9E-03	2E-03	3E-05	1E-02
			Chromium	4E-06	NA	2E-08	4E-06	Lung	8E-03	NA	4E-05	8E-03
			Cobalt	NA	NA	3E-09	3E-09	Thyroid/Respiratory System/Lung	2E-02	NA	2E-04	2E-02
			Iron	NA	NA	NA	NA	GI Tract	4E-02	NA	NA	4E-02
			Manganese	NA	NA	NA	NA	CNS	2E-03	NA	1E-03	4E-03
			Vanadium	NA	NA	3E-08	3E-08	Kidney/Respiratory System	8E-01	NA	9E-05	8E-01
			Chemical Total	6E-06	3E-07	5E-08	6E-06	Chemical Total	9E-01	2E-03	2E-03	9E-01
		Exposure Point Total					6E-06					9E-01
	Exposure Medium Total						6E-06					9E-01
Medium Total							6E-06					9E-01

TABLE B-9.5
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	3E-01	NA	NA	3E-01
			Tetrachloroethene	7E-09	9E-09	2E-08	4E-08	Liver	2E-03	2E-03	7E-03	1E-02
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	1E-03	2E-04	1E-02	1E-02
			Trichloroethene	9E-08	3E-08	2E-07	4E-07	Heart/ Immunogical/ Developmental/Kidney	1E-02	4E-03	8E-02	1E-01
			Vinyl Chloride	2E-06	2E-07	4E-07	2E-06	Liver	2E-03	3E-04	2E-03	5E-03
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	2E-02	2E-04	NA	2E-02
			Arsenic	2E-05	2E-07	NA	2E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	1E-03	NA	1E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	1E-02	1E-03	NA	1E-02
			Chromium	1E-05	2E-07	NA	1E-05	Lung	3E-02	1E-02	NA	4E-02
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	4E-02	1E-04	NA	4E-02
			Copper	NA	NA	NA	NA	GI Tract	1E-02	1E-04	NA	1E-02
			Iron	NA	NA	NA	NA	GI Tract	1E-01	1E-03	NA	1E-01
			Manganese	NA	NA	NA	NA	CNS	3E-02	8E-03	NA	4E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	1E+00	NA	3E+00
			Chemical Total	4E-05	6E-07	6E-07	4E-05	Chemical Total	3E+00	1E+00	1E-01	4E+00
		Exposure Point Total					4E-05					4E+00
	Exposure Medium Total						4E-05					4E+00
Medium Total							4E-05					4E+00
Receptor Total							4E-05					5E+00

Total Excess Cancer Risk Across All Media	4E-05	Total Hazard Index Across All Media	5

Blood HI Across All Media =	0.01
Liver HI Across All Media =	0.03
Kidney HI Across All Media =	4
CNS HI Across All Media =	0.2
Development HI Across All Media =	0.2
Respiratory System HI Across All Media =	4
Lung HI Across All Media =	0.3
Cardiovascular System HI Across All Media =	0.1
Skin HI Across All Media =	0.1
Heart HI Across All Media =	0.1
GI Tract HI Across All Media =	0.2
Fetus HI Across All Media =	0.01

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.6
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Aluminum	NA	NA	NA	NA	Neurological	1E-02	NA	2E-03	1E-02
			Arsenic	3E-07	2E-08	2E-11	3E-07	Skin/Developmental/ Cardiovascular System/CNS	7E-03	6E-04	1E-05	8E-03
			Chromium	8E-07	NA	4E-10	8E-07	None reported	6E-03	NA	2E-04	7E-03
			Cobalt	NA	NA	8E-11	8E-11	Thyroid	2E-02	NA	8E-04	2E-02
			Iron	NA	NA	NA	NA	GI Tract	3E-02	NA	NA	3E-02
			Manganese	NA	NA	NA	NA	CNS	2E-03	NA	2E-03	3E-03
			Vanadium	NA	NA	7E-10	7E-10	Kidney/Respiratory System/Eyes	6E-01	NA	1E-06	6E-01
			Chemical Total	1E-06	2E-08	1E-09	1E-06	Chemical Total	7E-01	6E-04	4E-03	7E-01
		Exposure Point Total					1E-06					7E-01
	Exposure Medium Total						1E-06					7E-01
Medium Total							1E-06					7E-01
Receptor Total							1E-06					7E-01

Total Excess Cancer Risk Across All Media	1E-06
Total Hazard Index Across All Media	0.7

Kidney HI Across All Media =	0.6
CNS HI Across All Media =	0.01
Development HI Across All Media =	<0.01
Respiratory System HI Across All Media =	0.6
Eyes HI Across All Media =	0.6
Cardiovascular System HI Across All Media =	<0.01
Skin HI Across All Media =	<0.01
GI Tract HI Across All Media =	0.03

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.7
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Aluminum	NA	NA	NA	NA	Neurological	2E-01	NA	2E-03	2E-01
			Arsenic	7E-06	6E-07	4E-09	7E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	1E-02	1E-04	1E-01
			Chromium	2E-05	NA	9E-08	2E-05	Lung	1E-01	NA	2E-04	1E-01
			Cobalt	NA	NA	2E-08	2E-08	Thyroid/Respiratory System/Lung	3E-01	NA	7E-04	3E-01
			Iron	NA	NA	NA	NA	GI Tract	5E-01	NA	NA	5E-01
			Manganese	NA	NA	NA	NA	CNS	3E-02	NA	5E-03	4E-02
			Vanadium	NA	NA	1E-07	1E-07	Kidney/Respiratory System	1E+01	NA	4E-04	1E+01
			Chemical Total	3E-05	6E-07	3E-07	3E-05	Chemical Total	1E+01	1E-02	8E-03	1E+01
		Exposure Point Total					3E-05					1E+01
	Exposure Medium Total						3E-05					1E+01
Medium Total							3E-05					1E+01

TABLE B-9.7
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	2E+00	NA	NA	2E+00
			Tetrachloroethene	3E-08	2E-08	6E-08	1E-07	Liver	1E-02	5E-03	3E-02	4E-02
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	7E-03	5E-04	5E-02	6E-02
			Trichloroethene	6E-07	9E-08	9E-10	6E-07	Heart/ Immunogical/ Developmental/Kidney	7E-02	1E-02	3E-01	4E-01
			Vinyl Chloride	4E-05	2E-06	5E-06	5E-05	Liver	2E-02	7E-04	1E-02	3E-02
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	1E-01	6E-04	NA	1E-01
			Arsenic	8E-05	5E-07	NA	9E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	8E-01	4E-03	NA	8E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	7E-02	4E-03	NA	7E-02
			Chromium	6E-05	3E-07	NA	6E-05	Lung	2E-01	3E-02	NA	2E-01
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	2E-01	4E-04	NA	2E-01
			Copper	NA	NA	NA	NA	GI Tract	8E-02	4E-04	NA	8E-02
			Iron	NA	NA	NA	NA	GI Tract	7E-01	3E-03	NA	8E-01
			Manganese	NA	NA	NA	NA	CNS	2E-01	2E-02	NA	2E-01
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+01	3E+00	NA	2E+01
			Chemical Total	2E-04	3E-06	5E-06	2E-04	Chemical Total	2E+01	3E+00	4E-01	2E+01
		Exposure Point Total					2E-04					2E+01
	Exposure Medium Total						2E-04					2E+01
Medium Total							2E-04					2E+01
Receptor Total							2E-04					3E+01

Total Excess Cancer Risk Across All Media	2E-04
Total Hazard Index Across All Media	34

Blood HI Across All Media =	0.06
Liver HI Across All Media =	0.1
Kidney HI Across All Media =	31
CNS HI Across All Media =	1
Development HI Across All Media =	1
Respiratory System HI Across All Media =	29
Lung HI Across All Media =	2
Cardiovascular System HI Across All Media =	0.9
Skin HI Across All Media =	0.9
Heart HI Across All Media =	0.4
GI Tract HI Across All Media =	1
Fetus HI Across All Media =	0.07

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.8
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Construction Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Puerto Rico Beverage	**Inorganics**									
			Aluminum	NA	NA	NA	NA	Neurological	2E-02	NA	2E-04	2E-02
			Arsenic	2E-08	2E-09	3E-12	2E-08	Skin/Developmental/ Cardiovascular System/CNS/Lung	3E-03	3E-04	3E-06	3E-03
			Chromium	5E-08	NA	7E-11	5E-08	Lung	2E-03	NA	4E-06	3E-03
			Cobalt	NA	NA	7E-11	7E-11	Thyroid/Respiratory System/Lung	3E-02	NA	9E-05	4E-02
			Iron	NA	NA	NA	NA	GI Tract	5E-02	NA	NA	5E-02
			Manganese	NA	NA	NA	NA	CNS	3E-03	NA	4E-04	3E-03
			Vanadium	NA	NA	7E-10	7E-10	Kidney/Respiratory System	2E+00	NA	6E-05	2E+00
			Chemical Total	7E-08	2E-09	8E-10	8E-08	Chemical Total	2E+00	3E-04	8E-04	2E+00
		Exposure Point Total					8E-08					2E+00
	Exposure Medium Total						8E-08					2E+00
Medium Total							8E-08					2E+00
Receptor Total							8E-08					2E+00

Total Excess Cancer Risk Across All Media	8E-08
Total Hazard Index Across All Media	2

Kidney HI Across All Media =	2
CNS HI Across All Media =	<0.01
Development HI Across All Media =	<0.01
Respiratory System HI Across All Media =	2
Lung HI Across All Media =	0.04
Cardiovascular System HI Across All Media =	<0.01
Skin HI Across All Media =	<0.01
GI Tract HI Across All Media =	0.05

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.9
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Recreational Users
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Sediment	Sediment	Maunabo River	**Inorganics**									
			Arsenic	5E-07	1E-07	NA	6E-07	Skin	1E-02	3E-03	NA	2E-02
			Chromium	3E-07	NA	NA	3E-07	None reported	2E-03	NA	NA	2E-03
			Cobalt	NA	NA	NA	NA	Thyroid	2E-02	NA	NA	2E-02
			Iron	NA	NA	NA	NA	GI Tract	2E-02	NA	NA	2E-02
			Manganese	NA	NA	NA	NA	CNS	3E-03	NA	NA	3E-03
			Vanadium	NA	NA	NA	NA	Kidney	1E+00	NA	NA	1E+00
			Chemical Total	7E-07	1E-07	--	9E-07	Chemical Total	1E+00	3E-03	--	1E+00
		Exposure Point Total					9E-07					1E+00
	Exposure Medium Total						9E-07					1E+00
Medium Total							9E-07					1E+00
Surface Water	Surface Water	Maunabo River	**Volatile Organic Compounds**									
			Bromodichloromethane	4E-09	9E-09	NA	1E-08	Liver	3E-05	9E-05	NA	1E-04
			Dibromochloromethane	6E-09	2E-08	NA	2E-08	Liver	4E-05	1E-04	NA	1E-04
			Chemical Total	1E-08	2E-08	--	3E-08	Chemical Total	8E-05	2E-04	--	3E-04
		Exposure Point Total					3E-08					3E-04
	Exposure Medium Total						3E-08					3E-04
Medium Total							3E-08					3E-04
Receptor Total							9E-07					1E+00

Total Excess Cancer Risk Across All Media	9E-07
Total Hazard Index Across All Media	1

Liver HI Across All Media =	<0.01
Kidney HI Across All Media =	1
CNS HI Across All Media =	<0.01
Skin HI Across All Media =	0.02
GI Tract HI Across All Media =	0.02

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE B-9.10
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Water	Surface Water	Tap Water	**Volatile Organic Compounds**									
			Bromodichloromethane	9E-07	NA	9E-06	1E-05	Liver	3E-03	NA	NA	3E-03
			Dibromochloromethane	2E-06	NA	9E-06	1E-05	Liver	4E-03	NA	NA	4E-03
			Chemical Total	3E-06	--	2E-05	2E-05	Chemical Total	7E-03	--	--	7E-03
		Exposure Point Total					2E-05					7E-03
	Exposure Medium Total						2E-05					7E-03
Medium Total							2E-05					7E-03
Receptor Total							2E-05					7E-03

Total Excess Cancer Risk Across All Media: 2E-05

Total Hazard Index Across All Media: 0.007

Liver HI Across All Media = <0.01

NA = not applicable

CNS = central nervous system

GI = gastrointestinal

TABLE B-10.1
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Inorganics**									
			Arsenic	2E-06	4E-07	9E-10	2E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-02	2E-03	4E-05	1E-02
			Chromium	3E-06	NA	1E-08	3E-06	Lung	5E-03	NA	3E-05	5E-03
			Chemical Total	5E-06	6E-07	5E-08	5E-06	Chemical Total	1E+00	2E-03	3E-03	1E+00
		Exposure Point Total					5E-06					1E+00
	Exposure Medium Total						5E-06					1E+00
Medium Total							5E-06					1E+00
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			Vinyl Chloride	2E-06	2E-07	4E-07	2E-06	Liver	2E-03	3E-04	2E-03	5E-03
			Inorganics									
			Arsenic	2E-05	2E-07	NA	2E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	1E-03	NA	1E-01
			Chromium	1E-05	2E-07	NA	1E-05	Lung	3E-02	1E-02	NA	4E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	1E+00	NA	3E+00
			Chemical Total	4E-05	6E-07	6E-07	4E-05	Chemical Total	3E+00	1E+00	1E-01	4E+00
		Exposure Point Total					4E-05					4E+00
	Exposure Medium Total						4E-05					4E+00
Medium Total							4E-05					4E+00
Receptor Total							4E-05					5E+00

Total Excess Cancer Risk Across All Media: 4E-05

Total Hazard Index Across All Media: 5

Kidney HI Across All Media = 5

Respiratory System HI Across All Media = 4

NA = not applicable
CNS = central nervous system
GI = gastrointestinal

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.2
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	Chemical Total	9E-07	4E-08	1E-09	9E-07	Chemical Total	8E-01	7E-04	5E-03	8E-01
		Exposure Point Total					9E-07					8E-01
	Exposure Medium Total						9E-07					8E-01
Medium Total							9E-07					8E-01
Receptor Total							9E-07					8E-01

Total Excess Cancer Risk Across All Media: 9E-07

Total Hazard Index Across All Media: 0.8

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.3
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	3E-06	1E-06	6E-11	4E-06	NA	NA	NA	NA	NA
			Dibenzo(a,h)anthracene	9E-07	3E-07	2E-11	1E-06	NA	NA	NA	NA	NA
			Inorganics									
			Arsenic	9E-06	8E-07	5E-09	9E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	2E-01	1E-02	2E-04	2E-01
			Chromium	1E-05	NA	5E-08	1E-05	Lung	6E-02	NA	1E-04	6E-02
			Vanadium	NA	NA	2E-07	2E-07	Kidney/Respiratory System	1E+01	NA	4E-04	1E+01
			Chemical Total	2E-05	2E-06	2E-07	3E-05	Chemical Total	1E+01	1E-02	1E-02	1E+01
		Exposure Point Total					3E-05					1E+01
	Exposure Medium Total						3E-05					1E+01
Medium Total							3E-05					1E+01
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	2E+00	NA	NA	2E+00
			Vinyl Chloride	4E-05	2E-06	5E-06	5E-05	Liver	2E-02	7E-04	1E-02	3E-02
			Inorganics									
			Arsenic	8E-05	5E-07	NA	9E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	8E-01	4E-03	NA	8E-01
			Chromium	6E-05	3E-07	NA	6E-05	Lung	2E-01	3E-02	NA	2E-01
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+01	3E+00	NA	2E+01
			Chemical Total	2E-04	3E-06	5E-06	2E-04	Chemical Total	2E+01	3E+00	4E-01	2E+01
		Exposure Point Total					2E-04					2E+01
	Exposure Medium Total						2E-04					2E+01
Medium Total							2E-04					2E+01
Receptor Total							2E-04					4E+01

Total Excess Cancer Risk Across All Media	2E-04
Total Hazard Index Across All Media	36

Kidney HI Across All Media =	32
CNS HI Across All Media =	1
Development HI Across All Media =	1
Respiratory System HI Across All Media =	30
Lung HI Across All Media =	2
GI Tract HI Across All Media =	2

NA = not applicable CNS = central nervous system GI = gastrointestinal
Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.4
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Construction Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Former Sugar Mill	**Inorganics**									
			Vanadium	NA	NA	8E-10	8E-10	Kidney/Respiratory System	2E+00	NA	6E-05	2E+00
			Chemical Total	2E-07	8E-09	1E-09	2E-07	Chemical Total	2E+00	7E-04	1E-03	2E+00
		Exposure Point Total					2E-07					2E+00
	Exposure Medium Total						2E-07					2E+00
Medium Total							2E-07					2E+00
Receptor Total							2E-07					2E+00

Total Excess Cancer Risk Across All Media: 2E-07

Total Hazard Index Across All Media: 2

Kidney HI Across All Media = 2

Respiratory System HI Across All Media = 2

NA = not applicable CNS = central nervous system GI = gastrointestinal

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.5
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Arsenic	2E-06	3E-07	7E-10	2E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	9E-03	2E-03	3E-05	1E-02
			Chromium	4E-06	NA	2E-08	4E-06	Lung	8E-03	NA	4E-05	8E-03
			Chemical Total	6E-06	3E-07	5E-08	6E-06	Chemical Total	9E-01	2E-03	2E-03	9E-01
		Exposure Point Total					6E-06					9E-01
	Exposure Medium Total						6E-06					9E-01
Medium Total							6E-06					9E-01
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			Vinyl Chloride	2E-06	2E-07	4E-07	2E-06	Liver	2E-03	3E-04	2E-03	5E-03
			Inorganics									
			Arsenic	2E-05	2E-07	NA	2E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	1E-03	NA	1E-01
			Chromium	1E-05	2E-07	NA	1E-05	Lung	3E-02	1E-02	NA	4E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	1E+00	NA	3E+00
			Chemical Total	4E-05	6E-07	6E-07	4E-05	Chemical Total	3E+00	1E+00	1E-01	4E+00
		Exposure Point Total					4E-05					4E+00
	Exposure Medium Total						4E-05					4E+00
Medium Total							4E-05					4E+00
Receptor Total							4E-05					5E+00

Total Excess Cancer Risk Across All Media: 4E-05

Total Hazard Index Across All Media: 5

Kidney HI Across All Media = 4

Respiratory System HI Across All Media = 4

NA = not applicable
CNS = central nervous system
GI = gastrointestinal

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.6
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	Chemical Total	1E-06	2E-08	1E-09	1E-06	Chemical Total	7E-01	6E-04	4E-03	7E-01
		Exposure Point Total					1E-06					7E-01
	Exposure Medium Total						1E-06					7E-01
Medium Total							1E-06					7E-01
Receptor Total							1E-06					7E-01

Total Excess Cancer Risk Across All Media: 1E-06

Total Hazard Index Across All Media: 0.7

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.7
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Arsenic	7E-06	6E-07	4E-09	7E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	1E-02	1E-04	1E-01
			Chromium	2E-05	NA	9E-08	2E-05	Lung	1E-01	NA	2E-04	1E-01
			Vanadium	NA	NA	1E-07	1E-07	Kidney/Respiratory System	1E+01	NA	4E-04	1E+01
			Chemical Total	3E-05	6E-07	3E-07	3E-05	Chemical Total	1E+01	1E-02	8E-03	1E+01
		Exposure Point Total					3E-05					1E+01
	Exposure Medium Total						3E-05					1E+01
Medium Total							3E-05					1E+01
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	2E+00	NA	NA	2E+00
			Vinyl Chloride	4E-05	2E-06	5E-06	5E-05	Liver	2E-02	7E-04	1E-02	3E-02
			Inorganics									
			Arsenic	8E-05	5E-07	NA	9E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	8E-01	4E-03	NA	8E-01
			Chromium	6E-05	3E-07	NA	6E-05	Lung	2E-01	3E-02	NA	2E-01
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+01	3E+00	NA	2E+01
			Chemical Total	2E-04	3E-06	5E-06	2E-04	Chemical Total	2E+01	3E+00	4E-01	2E+01
		Exposure Point Total					2E-04					2E+01
	Exposure Medium Total						2E-04					2E+01
Medium Total							2E-04					2E+01
Receptor Total							2E-04					3E+01

Total Excess Cancer Risk Across All Media	2E-04
Total Hazard Index Across All Media	34

Kidney HI Across All Media =	31
CNS HI Across All Media =	1
Development HI Across All Media =	1
Respiratory System HI Across All Media =	29
Lung HI Across All Media =	2
GI Tract HI Across All Media =	1

NA = not applicable CNS = central nervous system GI = gastrointestinal
Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.8
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Construction Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface/ Subsurface Soil	Surface/ Subsurface Soil	Puerto Rico Beverage	**Inorganics**									
			Vanadium	NA	NA	7E-10	7E-10	Kidney/Respiratory System	2E+00	NA	6E-05	2E+00
			Chemical Total	7E-08	2E-09	8E-10	8E-08	Chemical Total	2E+00	3E-04	8E-04	2E+00
		Exposure Point Total					8E-08					2E+00
	Exposure Medium Total						8E-08					2E+00
Medium Total							8E-08					2E+00
Receptor Total							8E-08					2E+00

Total Excess Cancer Risk Across All Media: 8E-08

Total Hazard Index Across All Media: 2

Kidney HI Across All Media = 2
Respiratory System HI Across All Media = 2

NA = not applicable
CNS = central nervous system
GI = gastrointestinal

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.9
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Recreational Users
Receptor Age:	Adolescent (7-12 yrs)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Sediment	Sediment	Maunabo River	**Inorganics**									
			Vanadium	NA	NA	NA	NA	Kidney	1E+00	NA	NA	1E+00
			Chemical Total	7E-07	1E-07	--	9E-07	Chemical Total	1E+00	3E-03	--	1E+00
		Exposure Point Total					9E-07					1E+00
	Exposure Medium Total						9E-07					1E+00
Medium Total							9E-07					1E+00
Surface Water	Surface Water	Maunabo River	Chemical Total	1E-08	2E-08	--	3E-08	Chemical Total	8E-05	2E-04	--	3E-04
		Exposure Point Total					3E-08					3E-04
	Exposure Medium Total						3E-08					3E-04
Medium Total							3E-08					3E-04
Receptor Total							9E-07					1E+00

Total Excess Cancer Risk Across All Media: 9E-07

Total Hazard Index Across All Media: 1

Kidney HI Across All Media = 1

NA = not applicable CNS = central nervous system GI = gastrointestinal

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE B-10.10
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Water	Surface Water	Tap Water	**Volatile Organic Compounds**									
			Bromodichloromethane	9E-07	NA	9E-06	1E-05	Liver	3E-03	NA	NA	3E-03
			Dibromochloromethane	2E-06	NA	9E-06	1E-05	Liver	4E-03	NA	NA	4E-03
			Chemical Total	3E-06	--	2E-05	2E-05	Chemical Total	7E-03	--	--	7E-03
		Exposure Point Total					2E-05					7E-03
	Exposure Medium Total						2E-05					7E-03
Medium Total							2E-05					7E-03
Receptor Total							2E-05					7E-03

Total Excess Cancer Risk Across All Media: 2E-05

Total Hazard Index Across All Media: 0.007

NA = not applicable
CNS = central nervous system
GI = gastrointestinal

Note:
Only chemicals above EPA's threshold values are listed in this table

Appendix C

ProUCL Output for Chemicals of Potential Concern

Appendix C Contents
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	SS-FSM.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Benzo(a)pyrene

General Statistics

Number of Valid Data	6	Number of Detected Data	4
Number of Distinct Detected Data	4	Number of Non-Detect Data	2
		Percent Non-Detects	33.33%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	7.9	Minimum Detected	2.067
Maximum Detected	76	Maximum Detected	4.331
Mean of Detected	33.33	Mean of Detected	3.082
SD of Detected	32.07	SD of Detected	1.105
Minimum Non-Detect	96	Minimum Non-Detect	4.564
Maximum Non-Detect	96	Maximum Non-Detect	4.564

Warning: There are only 4 Distinct Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.874	Shapiro Wilk Test Statistic	0.882
5% Shapiro Wilk Critical Value	0.748	5% Shapiro Wilk Critical Value	0.748
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	38.22	Mean	3.345
SD	25.97	SD	0.948
95% DL/2 (t) UCL	59.58	95% H-Stat (DL/2) UCL	235.8
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	3.082
		SD in Log Scale	0.945
		Mean in Original Scale	30.99
		SD in Original Scale	26.78
		95% t UCL	53.02
		95% Percentile Bootstrap UCL	47.8
		95% BCA Bootstrap UCL	53.08
		95% H-UCL	179

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.497
Theta Star	67.11
nu star	3.973
A-D Test Statistic	0.392
5% A-D Critical Value	0.664
K-S Test Statistic	0.664
5% K-S Critical Value	0.401

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	7.9
Maximum	76
Mean	32.41
Median	25.27
SD	27.92
k star	0.846
Theta star	38.31
Nu star	10.15
AppChi2	4.036
95% Gamma Approximate UCL	81.5
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	33.33
SD	27.77
SE of Mean	16.03
95% KM (t) UCL	65.63
95% KM (z) UCL	59.7
95% KM (jackknife) UCL	67.38
95% KM (bootstrap t) UCL	80.54
95% KM (BCA) UCL	58
95% KM (Percentile Bootstrap) UCL	58.98
95% KM (Chebyshev) UCL	103.2
97.5% KM (Chebyshev) UCL	133.4
99% KM (Chebyshev) UCL	192.8

Potential UCLs to Use

95% KM (t) UCL	65.63
95% KM (Percentile Bootstrap) UCL	58.98

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Dibenzo(a,h)anthracene

General Statistics

Number of Valid Data	6	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	4
		Percent Non-Detects	66.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	12	Minimum Detected	2.485
Maximum Detected	18	Maximum Detected	2.89
Mean of Detected	15	Mean of Detected	2.688
SD of Detected	4.243	SD of Detected	0.287
Minimum Non-Detect	96	Minimum Non-Detect	4.564
Maximum Non-Detect	100	Maximum Non-Detect	4.605

Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	6
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	0
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	100.00%

Warning: Data set has only 2 Distinct Detected Values.
This may not be adequate enough to compute meaningful and reliable test statistics and estimates.
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Unless Data Quality Objectives (DQOs) have been met, it is suggested to collect additional observations.

The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	37.5	Mean	3.487
SD	17.55	SD	0.632
95% DL/2 (t) UCL	51.93	95% H-Stat (DL/2) UCL	92.74
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	N/A
		SD in Log Scale	N/A
		Mean in Original Scale	N/A
		SD in Original Scale	N/A
		95% t UCL	N/A
		95% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap UCL	N/A
		95% H-UCL	N/A

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Data Distribution Test with Detected Values Only	
Data do not follow a Discernable Distribution (0.05)	
Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	15
SD	3
SE of Mean	3
95% KM (t) UCL	21.05
95% KM (z) UCL	19.93
95% KM (jackknife) UCL	22.8
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	18
95% KM (Percentile Bootstrap) UCL	18
95% KM (Chebyshev) UCL	28.08
97.5% KM (Chebyshev) UCL	33.73
99% KM (Chebyshev) UCL	44.85
Potential UCLs to Use	
95% KM (t) UCL	21.05
95% KM (% Bootstrap) UCL	18

Warning: Recommended UCL exceeds the maximum observation

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Aluminum

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	5140	Minimum of Log Data	8.545
Maximum	15800	Maximum of Log Data	9.668
Mean	10513	Mean of log Data	9.194
Median	10070	SD of log Data	0.412
SD	3967		
Std. Error of Mean	1619		
Coefficient of Variation	0.377		
Skewness	0.0408		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.965	Shapiro Wilk Test Statistic	0.949
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	13777	95% H-UCL	16779
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	18276
95% Adjusted-CLT UCL (Chen-1995)	13206	97.5% Chebyshev (MVUE) UCL	21618
95% Modified-t UCL (Johnson-1978)	13781	99% Chebyshev (MVUE) UCL	28183

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	3.967
Theta Star	2650
MLE of Mean	10513
MLE of Standard Deviation	5279
nu star	47.6
Approximate Chi Square Value (.05)	32.77
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	28.39
Anderson-Darling Test Statistic	0.242
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.179
Kolmogorov-Smirnov 5% Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	15273
95% Adjusted Gamma UCL	17625

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	13177
95% Jackknife UCL	13777
95% Standard Bootstrap UCL	12951
95% Bootstrap-t UCL	13811
95% Hall's Bootstrap UCL	13379
95% Percentile Bootstrap UCL	12873
95% BCA Bootstrap UCL	12833
95% Chebyshev(Mean, Sd) UCL	17573
97.5% Chebyshev(Mean, Sd) UCL	20627
99% Chebyshev(Mean, Sd) UCL	26627

Potential UCL to Use

Use 95% Student's-t UCL 13777

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Arsenic

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.84	Minimum of Log Data	-0.174
Maximum	4.6	Maximum of Log Data	1.526
Mean	2.557	Mean of log Data	0.809
Median	2.5	SD of log Data	0.592
SD	1.311		
Std. Error of Mean	0.535		
Coefficient of Variation	0.513		
Skewness	0.407		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.984	Shapiro Wilk Test Statistic	0.962
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	3.635	95% H-UCL	5.724
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	5.314
95% Adjusted-CLT UCL (Chen-1995)	3.532	97.5% Chebyshev (MVUE) UCL	6.493
95% Modified-t UCL (Johnson-1978)	3.65	99% Chebyshev (MVUE) UCL	8.807

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test	
k star (bias corrected)	2.113
Theta Star	1.21
MLE of Mean	2.557
MLE of Standard Deviation	1.759
nu star	25.36
Approximate Chi Square Value (.05)	14.89
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	12.09
Anderson-Darling Test Statistic	0.177
Anderson-Darling 5% Critical Value	0.7
Kolmogorov-Smirnov Test Statistic	0.164
Kolmogorov-Smirnov 5% Critical Value	0.334

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution	
95% Approximate Gamma UCL	4.355
95% Adjusted Gamma UCL	5.363

Potential UCL to Use

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics	
95% CLT UCL	3.437
95% Jackknife UCL	3.635
95% Standard Bootstrap UCL	3.361
95% Bootstrap-t UCL	3.769
95% Hall's Bootstrap UCL	3.661
95% Percentile Bootstrap UCL	3.367
95% BCA Bootstrap UCL	3.383
95% Chebyshev(Mean, Sd) UCL	4.89
97.5% Chebyshev(Mean, Sd) UCL	5.9
99% Chebyshev(Mean, Sd) UCL	7.883

Use 95% Student's-t UCL 3.635

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Chromium

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	3	Minimum of Log Data	1.099
Maximum	17.1	Maximum of Log Data	2.839
Mean	9.8	Mean of log Data	2.065
Median	9.2	SD of log Data	0.759
SD	6.352		
Std. Error of Mean	2.593		
Coefficient of Variation	0.648		
Skewness	0.134		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.86	Shapiro Wilk Test Statistic	0.878
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	15.03	95% H-UCL	32.75
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	23.28
95% Adjusted-CLT UCL (Chen-1995)	14.22	97.5% Chebyshev (MVUE) UCL	29.05
95% Modified-t UCL (Johnson-1978)	15.05	99% Chebyshev (MVUE) UCL	40.39

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test	
k star (bias corrected)	1.336
Theta Star	7.336
MLE of Mean	9.8
MLE of Standard Deviation	8.479
nu star	16.03
Approximate Chi Square Value (.05)	7.983
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	6.048
Anderson-Darling Test Statistic	0.449
Anderson-Darling 5% Critical Value	0.703
Kolmogorov-Smirnov Test Statistic	0.233
Kolmogorov-Smirnov 5% Critical Value	0.335

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution	
95% Approximate Gamma UCL	19.68
95% Adjusted Gamma UCL	25.97

Potential UCL to Use

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics	
95% CLT UCL	14.07
95% Jackknife UCL	15.03
95% Standard Bootstrap UCL	13.68
95% Bootstrap-t UCL	16.67
95% Hall's Bootstrap UCL	12.81
95% Percentile Bootstrap UCL	13.77
95% BCA Bootstrap UCL	13.48
95% Chebyshev(Mean, Sd) UCL	21.1
97.5% Chebyshev(Mean, Sd) UCL	25.99
99% Chebyshev(Mean, Sd) UCL	35.6

Use 95% Student's-t UCL 15.03

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Cobalt

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	3	Minimum of Log Data	1.099
Maximum	10.5	Maximum of Log Data	2.351
Mean	6.4	Mean of log Data	1.768
Median	5.6	SD of log Data	0.467
SD	2.903		
Std. Error of Mean	1.185		
Coefficient of Variation	0.454		
Skewness	0.549		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.922	Shapiro Wilk Test Statistic	0.958
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	8.788	95% H-UCL	11.15
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	11.73
95% Adjusted-CLT UCL (Chen-1995)	8.633	97.5% Chebyshev (MVUE) UCL	14.03
95% Modified-t UCL (Johnson-1978)	8.832	99% Chebyshev (MVUE) UCL	18.55

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test	
k star (bias corrected)	3.012
Theta Star	2.125
MLE of Mean	6.4
MLE of Standard Deviation	3.688
nu star	36.14
Approximate Chi Square Value (.05)	23.38
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	19.76
Anderson-Darling Test Statistic	0.267
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.204
Kolmogorov-Smirnov 5% Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution	
95% Approximate Gamma UCL	9.892
95% Adjusted Gamma UCL	11.7

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics	
95% CLT UCL	8.349
95% Jackknife UCL	8.788
95% Standard Bootstrap UCL	8.182
95% Bootstrap-t UCL	11.12
95% Hall's Bootstrap UCL	28.69
95% Percentile Bootstrap UCL	8.267
95% BCA Bootstrap UCL	8.4
95% Chebyshev(Mean, Sd) UCL	11.57
97.5% Chebyshev(Mean, Sd) UCL	13.8
99% Chebyshev(Mean, Sd) UCL	18.19

Potential UCL to Use — Use 95% Student's-t UCL 8.788

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Iron

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	16600	Minimum of Log Data	9.717
Maximum	41800	Maximum of Log Data	10.64
Mean	28117	Mean of log Data	10.17
Median	27200	SD of log Data	0.42
SD	11327		
Std. Error of Mean	4624		
Coefficient of Variation	0.403		
Skewness	0.141		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.856	Shapiro Wilk Test Statistic	0.852
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	37435	95% H-UCL	45334
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	49157
95% Adjusted-CLT UCL (Chen-1995)	36007	97.5% Chebyshev (MVUE) UCL	58250
95% Modified-t UCL (Johnson-1978)	37479	99% Chebyshev (MVUE) UCL	76111

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	3.675
Theta Star	7651
MLE of Mean	28117
MLE of Standard Deviation	14667
nu star	44.1
Approximate Chi Square Value (.05)	29.87
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	25.71
Anderson-Darling Test Statistic	0.514
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.242
Kolmogorov-Smirnov 5% Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	41512
95% Adjusted Gamma UCL	48218

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	35723
95% Jackknife UCL	37435
95% Standard Bootstrap UCL	35040
95% Bootstrap-t UCL	37099
95% Hall's Bootstrap UCL	33031
95% Percentile Bootstrap UCL	34933
95% BCA Bootstrap UCL	34983
95% Chebyshev(Mean, Sd) UCL	48274
97.5% Chebyshev(Mean, Sd) UCL	56996
99% Chebyshev(Mean, Sd) UCL	74129

Potential UCL to Use

Use 95% Student's-t UCL 37435

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Manganese

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	221	Minimum of Log Data	5.398
Maximum	547	Maximum of Log Data	6.304
Mean	386.5	Mean of log Data	5.912
Median	364	SD of log Data	0.335
SD	124		
Std. Error of Mean	50.61		
Coefficient of Variation	0.321		
Skewness	0.191		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.935	Shapiro Wilk Test Statistic	0.943
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	488.5	95% H-UCL	550.7
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	617.8
95% Adjusted-CLT UCL (Chen-1995)	474	97.5% Chebyshev (MVUE) UCL	717.7
95% Modified-t UCL (Johnson-1978)	489.1	99% Chebyshev (MVUE) UCL	913.8

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test	
k star (bias corrected)	5.715
Theta Star	67.63
MLE of Mean	386.5
MLE of Standard Deviation	161.7
nu star	68.58
Approximate Chi Square Value (.05)	50.52
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	44.97
Anderson-Darling Test Statistic	0.285
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.199
Kolmogorov-Smirnov 5% Critical Value	0.332

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution	
95% Approximate Gamma UCL	524.7
95% Adjusted Gamma UCL	589.4

Potential UCL to Use

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics	
95% CLT UCL	469.7
95% Jackknife UCL	488.5
95% Standard Bootstrap UCL	460.9
95% Bootstrap-t UCL	530.9
95% Hall's Bootstrap UCL	605.4
95% Percentile Bootstrap UCL	462
95% BCA Bootstrap UCL	465.7
95% Chebyshev(Mean, Sd) UCL	607.1
97.5% Chebyshev(Mean, Sd) UCL	702.6
99% Chebyshev(Mean, Sd) UCL	890.1

Use 95% Student's-t UCL 488.5

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Vanadium

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	24.3	Minimum of Log Data	3.19
Maximum	69.3	Maximum of Log Data	4.238
Mean	48.77	Mean of log Data	3.822
Median	47.75	SD of log Data	0.408
SD	18.16		
Std. Error of Mean	7.416		
Coefficient of Variation	0.372		
Skewness	-0.0652		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!

If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data

Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.931	Shapiro Wilk Test Statistic	0.931
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	63.71	95% H-UCL	77.39
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	84.46
95% Adjusted-CLT UCL (Chen-1995)	60.75	97.5% Chebyshev (MVUE) UCL	99.82
95% Modified-t UCL (Johnson-1978)	63.68	99% Chebyshev (MVUE) UCL	130

Appendix C-1
ProUCL Output - Surface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	4.037
Theta Star	12.08
MLE of Mean	48.77
MLE of Standard Deviation	24.27
nu star	48.44
Approximate Chi Square Value (.05)	33.47
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	29.04
Anderson-Darling Test Statistic	0.27
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.2
Kolmogorov-Smirnov 5% Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	70.59
95% Adjusted Gamma UCL	81.35

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	60.96
95% Jackknife UCL	63.71
95% Standard Bootstrap UCL	59.81
95% Bootstrap-t UCL	65.64
95% Hall's Bootstrap UCL	61.53
95% Percentile Bootstrap UCL	59.8
95% BCA Bootstrap UCL	59
95% Chebyshev(Mean, Sd) UCL	81.09
97.5% Chebyshev(Mean, Sd) UCL	95.08
99% Chebyshev(Mean, Sd) UCL	122.6

Potential UCL to Use

Use 95% Student's-t UCL 63.71

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Note: For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	SS-PRB.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	7060	Minimum of Log Data	8.862
Maximum	15700	Maximum of Log Data	9.661
Mean	10240	Mean of log Data	9.192
Median	8825	SD of log Data	0.312
SD	3403		
Std. Error of Mean	1389		
Coefficient of Variation	0.332		
Skewness	1.02		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.868	Shapiro Wilk Test Statistic	0.906
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	13040	95% H-UCL	14104
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	15896
95% Adjusted-CLT UCL (Chen-1995)	13144	97.5% Chebyshev (MVUE) UCL	18352
95% Modified-t UCL (Johnson-1978)	13136	99% Chebyshev (MVUE) UCL	23177

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	6.092
Theta Star	1681
MLE of Mean	10240
MLE of Standard Deviation	4149
nu star	73.11
Approximate Chi Square Value (.05)	54.42
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	48.64
Anderson-Darling Test Statistic	0.425
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.256
Kolmogorov-Smirnov 5% Critical Value	0.332

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	13757
95% Adjusted Gamma UCL	15391

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	12525
95% Jackknife UCL	13040
95% Standard Bootstrap UCL	12300
95% Bootstrap-t UCL	17711
95% Hall's Bootstrap UCL	30933
95% Percentile Bootstrap UCL	12387
95% BCA Bootstrap UCL	12703
95% Chebyshev(Mean, Sd) UCL	16296
97.5% Chebyshev(Mean, Sd) UCL	18917
99% Chebyshev(Mean, Sd) UCL	24065

Potential UCL to Use

Use 95% Student's-t UCL 13040

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Arsenic

General Statistics

Number of Valid Data	6	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	4
		Percent Non-Detects	66.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.43	Minimum Detected	-0.844
Maximum Detected	2.9	Maximum Detected	1.065
Mean of Detected	1.665	Mean of Detected	0.11
SD of Detected	1.747	SD of Detected	1.35
Minimum Non-Detect	1.1	Minimum Non-Detect	0.0953
Maximum Non-Detect	1.1	Maximum Non-Detect	0.0953

Warning: Data set has only 2 Distinct Detected Values.

This may not be adequate enough to compute meaningful and reliable test statistics and estimates.

The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Unless Data Quality Objectives (DQOs) have been met, it is suggested to collect additional observations.

The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.

Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.

However, results obtained using 4 to 9 distinct values may not be reliable.

It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.922	Mean	-0.362
SD	0.97	SD	0.706
95% DL/2 (t) UCL	1.72	95% H-Stat (DL/2) UCL	2.444
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	N/A
		SD in Log Scale	N/A
		Mean in Original Scale	N/A
		SD in Original Scale	N/A
		95% t UCL	N/A
		95% Percentile Bootstrap UCL	N/A
		95% BCA Bootstrap UCL	N/A
		95% H-UCL	N/A

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.842
SD	0.921
SE of Mean	0.531
95% KM (t) UCL	1.913
95% KM (z) UCL	1.716
95% KM (jackknife) UCL	N/A
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	N/A
95% KM (Chebyshev) UCL	3.158
97.5% KM (Chebyshev) UCL	4.161
99% KM (Chebyshev) UCL	6.13

Potential UCLs to Use

95% KM (BCA) UCL	N/A

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Chromium

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	1.6	Minimum of Log Data	0.47
Maximum	27.5	Maximum of Log Data	3.314
Mean	6.967	Mean of log Data	1.337
Median	2.45	SD of log Data	1.063
SD	10.17		
Std. Error of Mean	4.152		
Coefficient of Variation	1.46		
Skewness	2.336		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.609	Shapiro Wilk Test Statistic	0.809
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	15.33	95% H-UCL	53.02
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	16.93
95% Adjusted-CLT UCL (Chen-1995)	18.03	97.5% Chebyshev (MVUE) UCL	21.68
95% Modified-t UCL (Johnson-1978)	15.99	99% Chebyshev (MVUE) UCL	31.03

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	0.591
Theta Star	11.78
MLE of Mean	6.967
MLE of Standard Deviation	9.06
nu star	7.096
Approximate Chi Square Value (.05)	2.223
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	1.371
Anderson-Darling Test Statistic	0.856
Anderson-Darling 5% Critical Value	0.716
Kolmogorov-Smirnov Test Statistic	0.347
Kolmogorov-Smirnov 5% Critical Value	0.341

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	22.23
95% Adjusted Gamma UCL	36.07

Potential UCL to Use

Data Distribution

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	13.8
95% Jackknife UCL	15.33
95% Standard Bootstrap UCL	13.2
95% Bootstrap-t UCL	132.7
95% Hall's Bootstrap UCL	76.6
95% Percentile Bootstrap UCL	14.67
95% BCA Bootstrap UCL	19
95% Chebyshev(Mean, Sd) UCL	25.07
97.5% Chebyshev(Mean, Sd) UCL	32.9
99% Chebyshev(Mean, Sd) UCL	48.28

Use 95% Chebyshev (Mean, Sd) UCL 25.07

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Cobalt

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	2.1	Minimum of Log Data	0.742
Maximum	7.5	Maximum of Log Data	2.015
Mean	4.783	Mean of log Data	1.489
Median	4.55	SD of log Data	0.447
SD	1.913		
Std. Error of Mean	0.781		
Coefficient of Variation	0.4		
Skewness	0.122		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.986	Shapiro Wilk Test Statistic	0.957
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	6.357	95% H-UCL	8.095
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	8.634
95% Adjusted-CLT UCL (Chen-1995)	6.109	97.5% Chebyshev (MVUE) UCL	10.29
95% Modified-t UCL (Johnson-1978)	6.363	99% Chebyshev (MVUE) UCL	13.54

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	3.468
Theta Star	1.379
MLE of Mean	4.783
MLE of Standard Deviation	2.568
nu star	41.62
Approximate Chi Square Value (.05)	27.83
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	23.84
Anderson-Darling Test Statistic	0.192
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.142
Kolmogorov-Smirnov 5% Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	7.153
95% Adjusted Gamma UCL	8.351

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	6.068
95% Jackknife UCL	6.357
95% Standard Bootstrap UCL	5.964
95% Bootstrap-t UCL	6.752
95% Hall's Bootstrap UCL	7.022
95% Percentile Bootstrap UCL	6
95% BCA Bootstrap UCL	5.933
95% Chebyshev(Mean, Sd) UCL	8.187
97.5% Chebyshev(Mean, Sd) UCL	9.659
99% Chebyshev(Mean, Sd) UCL	12.55

Potential UCL to Use

Use 95% Student's-t UCL 6.357

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Iron

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	16400	Minimum of Log Data	9.705
Maximum	35900	Maximum of Log Data	10.49
Mean	23467	Mean of log Data	10.03
Median	22500	SD of log Data	0.294
SD	7258		
Std. Error of Mean	2963		
Coefficient of Variation	0.309		
Skewness	1.035		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.907	Shapiro Wilk Test Statistic	0.942
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	29438	95% H-UCL	31611
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	35713
95% Adjusted-CLT UCL (Chen-1995)	29679	97.5% Chebyshev (MVUE) UCL	41025
95% Modified-t UCL (Johnson-1978)	29646	99% Chebyshev (MVUE) UCL	51459

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test	
k star (bias corrected)	6.907
Theta Star	3397
MLE of Mean	23467
MLE of Standard Deviation	8929
nu star	82.89
Approximate Chi Square Value (.05)	62.91
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	56.66
Anderson-Darling Test Statistic	0.283
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.179
Kolmogorov-Smirnov 5% Critical Value	0.332

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution	
95% Approximate Gamma UCL	30921
95% Adjusted Gamma UCL	34331

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics	
95% CLT UCL	28341
95% Jackknife UCL	29438
95% Standard Bootstrap UCL	27796
95% Bootstrap-t UCL	32251
95% Hall's Bootstrap UCL	30768
95% Percentile Bootstrap UCL	28333
95% BCA Bootstrap UCL	29000
95% Chebyshev(Mean, Sd) UCL	36383
97.5% Chebyshev(Mean, Sd) UCL	41972
99% Chebyshev(Mean, Sd) UCL	52950

Potential UCL to Use Use 95% Student's-t UCL 29438

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Manganese

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	135	Minimum of Log Data	4.905
Maximum	365	Maximum of Log Data	5.9
Mean	269.3	Mean of log Data	5.531
Median	300	SD of log Data	0.414
SD	96.46		
Std. Error of Mean	39.38		
Coefficient of Variation	0.358		
Skewness	-0.608		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.88	Shapiro Wilk Test Statistic	0.855
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	348.7	95% H-UCL	432.1
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	470.2
95% Adjusted-CLT UCL (Chen-1995)	323.7	97.5% Chebyshev (MVUE) UCL	556.4
95% Modified-t UCL (Johnson-1978)	347.1	99% Chebyshev (MVUE) UCL	725.8

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	4.047
Theta Star	66.56
MLE of Mean	269.3
MLE of Standard Deviation	133.9
nu star	48.56
Approximate Chi Square Value (.05)	33.56
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	29.13
Anderson-Darling Test Statistic	0.492
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.266
Kolmogorov-Smirnov 5% Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	389.7
95% Adjusted Gamma UCL	448.9

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	334.1
95% Jackknife UCL	348.7
95% Standard Bootstrap UCL	327.9
95% Bootstrap-t UCL	334.7
95% Hall's Bootstrap UCL	312.7
95% Percentile Bootstrap UCL	326.8
95% BCA Bootstrap UCL	320
95% Chebyshev(Mean, Sd) UCL	441
97.5% Chebyshev(Mean, Sd) UCL	515.3
99% Chebyshev(Mean, Sd) UCL	661.2

Potential UCL to Use

Use 95% Student's-t UCL 348.7

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Note: For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Vanadium

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	31.9	Minimum of Log Data	3.463
Maximum	71.8	Maximum of Log Data	4.274
Mean	43.95	Mean of log Data	3.739
Median	37.5	SD of log Data	0.312
SD	15.34		
Std. Error of Mean	6.263		
Coefficient of Variation	0.349		
Skewness	1.527		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.82	Shapiro Wilk Test Statistic	0.87
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	56.57	95% H-UCL	60.47
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	68.15
95% Adjusted-CLT UCL (Chen-1995)	58.42	97.5% Chebyshev (MVUE) UCL	78.69
95% Modified-t UCL (Johnson-1978)	57.22	99% Chebyshev (MVUE) UCL	99.38

Appendix C-2
ProUCL Output - Surface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	5.902
Theta Star	7.447
MLE of Mean	43.95
MLE of Standard Deviation	18.09
nu star	70.82
Approximate Chi Square Value (.05)	52.44
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	46.78
Anderson-Darling Test Statistic	0.496
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.249
Kolmogorov-Smirnov 5% Critical Value	0.332

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	59.35
95% Adjusted Gamma UCL	66.53

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	54.25
95% Jackknife UCL	56.57
95% Standard Bootstrap UCL	53.15
95% Bootstrap-t UCL	80.02
95% Hall's Bootstrap UCL	104.5
95% Percentile Bootstrap UCL	53.82
95% BCA Bootstrap UCL	56.45
95% Chebyshev(Mean, Sd) UCL	71.25
97.5% Chebyshev(Mean, Sd) UCL	83.06
99% Chebyshev(Mean, Sd) UCL	106.3

Potential UCL to Use

Use 95% Student's-t UCL 56.57

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Appendix C-3
ProUCL Output - Surface/Subsurface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	SB-FSM.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Benzo(a)pyrene

General Statistics

Number of Valid Data	24	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	17
		Percent Non-Detects	70.83%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	7.9	Minimum Detected	2.067
Maximum Detected	76	Maximum Detected	4.331
Mean of Detected	29.21	Mean of Detected	3.008
SD of Detected	26.09	SD of Detected	0.937
Minimum Non-Detect	96	Minimum Non-Detect	4.564
Maximum Non-Detect	120	Maximum Non-Detect	4.787

Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	24
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	0
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	100.00%

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.838	Shapiro Wilk Test Statistic	0.872
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	46.21	Mean	3.69
SD	17.72	SD	0.658
95% DL/2 (t) UCL	52.41	95% H-Stat (DL/2) UCL	66.68
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	3.008
		SD in Log Scale	0.742
		Mean in Original Scale	26.23
		SD in Original Scale	19.56
		95% t UCL	33.08
		95% Percentile Bootstrap UCL	33.19
		95% BCA Bootstrap UCL	33.87
		95% H-UCL	37.62

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.957
Theta Star	30.53
nu star	13.39
A-D Test Statistic	0.503
5% A-D Critical Value	0.721
K-S Test Statistic	0.721
5% K-S Critical Value	0.317

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	76
Mean	29.23
Median	28.83
SD	20.74
k star	0.589
Theta star	49.65
Nu star	28.26
AppChi2	17.13
95% Gamma Approximate UCL	48.22
95% Adjusted Gamma UCL	50

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	29.21
SD	24.16
SE of Mean	9.862
95% KM (t) UCL	46.12
95% KM (z) UCL	45.44
95% KM (jackknife) UCL	47.09
95% KM (bootstrap t) UCL	60.31
95% KM (BCA) UCL	46.4
95% KM (Percentile Bootstrap) UCL	44.88
95% KM (Chebyshev) UCL	72.2
97.5% KM (Chebyshev) UCL	90.8
99% KM (Chebyshev) UCL	127.3

Potential UCLs to Use

95% KM (t) UCL	46.12
95% KM (Percentile Bootstrap) UCL	44.88

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Dibenzo(a,h)anthracene

General Statistics

Number of Valid Data	24	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	21
		Percent Non-Detects	87.50%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	8.6	Minimum Detected	2.152
Maximum Detected	18	Maximum Detected	2.89
Mean of Detected	12.87	Mean of Detected	2.509
SD of Detected	4.76	SD of Detected	0.37
Minimum Non-Detect	96	Minimum Non-Detect	4.564
Maximum Non-Detect	120	Maximum Non-Detect	4.787

Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	24
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	0
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	100.00%

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.975	Shapiro Wilk Test Statistic	0.997
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	47.57	Mean	3.777
SD	13.99	SD	0.507
95% DL/2 (t) UCL	52.46	95% H-Stat (DL/2) UCL	61.28
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	2.509
		SD in Log Scale	0.341
		Mean in Original Scale	12.99
		SD in Original Scale	4.415
		95% t UCL	14.53
		95% Percentile Bootstrap UCL	14.53
		95% BCA Bootstrap UCL	14.56
		95% H-UCL	14.86

Appendix C-3
ProUCL Output - Surface/Subsurface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only	
Data appear Normal at 5% Significance Level	

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	12.87
SD	3.886
SE of Mean	2.748
95% KM (t) UCL	17.58
95% KM (z) UCL	17.39
95% KM (jackknife) UCL	18.51
95% KM (bootstrap t) UCL	23.91
95% KM (BCA) UCL	18
95% KM (Percentile Bootstrap) UCL	18
95% KM (Chebyshev) UCL	24.84
97.5% KM (Chebyshev) UCL	30.03
99% KM (Chebyshev) UCL	40.21
Potential UCLs to Use	
95% KM (t) UCL	17.58
95% KM (Percentile Bootstrap) UCL	18

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Aluminum

General Statistics

Number of Valid Observations	24	Number of Distinct Observations	24

Raw Statistics		**Log-transformed Statistics**	
Minimum	5140	Minimum of Log Data	8.545
Maximum	28500	Maximum of Log Data	10.26
Mean	15516	Mean of log Data	9.593
Median	15750	SD of log Data	0.364
SD	4996		
Std. Error of Mean	1020		
Coefficient of Variation	0.322		
Skewness	0.268		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.973	Shapiro Wilk Test Statistic	0.93
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	17264	95% H-UCL	18047
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	20780
95% Adjusted-CLT UCL (Chen-1995)	17253	97.5% Chebyshev (MVUE) UCL	23015
95% Modified-t UCL (Johnson-1978)	17273	99% Chebyshev (MVUE) UCL	27406

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	7.85	**Data appear Normal at 5% Significance Level**
Theta Star	1977	
MLE of Mean	15516	
MLE of Standard Deviation	5538	
nu star	376.8	
Approximate Chi Square Value (.05)	332.8	
Adjusted Level of Significance	0.0392	
Adjusted Chi Square Value	329.9	
Anderson-Darling Test Statistic	0.394	
Anderson-Darling 5% Critical Value	0.745	
Kolmogorov-Smirnov Test Statistic	0.112	
Kolmogorov-Smirnov 5% Critical Value	0.178	
Data appear Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution	
95% Approximate Gamma UCL	17567
95% Adjusted Gamma UCL	17721

Nonparametric Statistics	
95% CLT UCL	17193
95% Jackknife UCL	17264
95% Standard Bootstrap UCL	17155
95% Bootstrap-t UCL	17286
95% Hall's Bootstrap UCL	17504
95% Percentile Bootstrap UCL	17208
95% BCA Bootstrap UCL	17253
95% Chebyshev(Mean, Sd) UCL	19961
97.5% Chebyshev(Mean, Sd) UCL	21885
99% Chebyshev(Mean, Sd) UCL	25664

Potential UCL to Use	Use 95% Student's-t UCL 17264

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Arsenic

General Statistics

Number of Valid Data	24	Number of Detected Data	14
Number of Distinct Detected Data	14	Number of Non-Detect Data	10
		Percent Non-Detects	41.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.29	Minimum Detected	-1.238
Maximum Detected	4.6	Maximum Detected	1.526
Mean of Detected	2.089	Mean of Detected	0.463
SD of Detected	1.342	SD of Detected	0.859
Minimum Non-Detect	1.2	Minimum Non-Detect	0.182
Maximum Non-Detect	1.4	Maximum Non-Detect	0.336

Note: Data have multiple DLs - Use of KM Method is recommended
For all methods (except KM, DL/2, and ROS Methods),
Observations < Largest ND are treated as NDs

Number treated as Non-Detect	15
Number treated as Detected	9
Single DL Non-Detect Percentage	62.50%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.956	Shapiro Wilk Test Statistic	0.918
5% Shapiro Wilk Critical Value	0.874	5% Shapiro Wilk Critical Value	0.874
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	1.485	Mean	0.0835
SD	1.245	SD	0.792
95% DL/2 (t) UCL	1.921	95% H-Stat (DL/2) UCL	2.17
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.844	Mean in Log Scale	0.041
SD	1.951	SD in Log Scale	0.868
95% MLE (t) UCL	1.526	Mean in Original Scale	1.48
95% MLE (Tiku) UCL	1.844	SD in Original Scale	1.259
		95% t UCL	1.92
		95% Percentile Bootstrap UCL	1.891
		95% BCA Bootstrap UCL	1.984
		95% H UCL	2.333

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.601
Theta Star	1.305
nu star	44.81
A-D Test Statistic	0.331
5% A-D Critical Value	0.746
K-S Test Statistic	0.746
5% K-S Critical Value	0.232

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	4.6
Mean	1.501
Median	1.184
SD	1.291
k star	0.336
Theta star	4.461
Nu star	16.15
AppChi2	8.067
95% Gamma Approximate UCL	3.004
95% Adjusted Gamma UCL	3.161

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	1.465
SD	1.244
SE of Mean	0.27
95% KM (t) UCL	1.928
95% KM (z) UCL	1.91
95% KM (jackknife) UCL	1.927
95% KM (bootstrap t) UCL	2.005
95% KM (BCA) UCL	1.925
95% KM (Percentile Bootstrap) UCL	1.913
95% KM (Chebyshev) UCL	2.642
97.5% KM (Chebyshev) UCL	3.152
99% KM (Chebyshev) UCL	4.152

Potential UCLs to Use

95% KM (t) UCL	1.928
95% KM (Percentile Bootstrap) UCL	1.913

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Chromium

General Statistics

Number of Valid Observations	24	Number of Distinct Observations	20

Raw Statistics		**Log-transformed Statistics**	
Minimum	3	Minimum of Log Data	1.099
Maximum	20.8	Maximum of Log Data	3.035
Mean	8.283	Mean of log Data	2.004
Median	6.9	SD of log Data	0.46
SD	4.453		
Std. Error of Mean	0.909		
Coefficient of Variation	0.538		
Skewness	1.617		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.785	Shapiro Wilk Test Statistic	0.915
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	9.841	95% H-UCL	9.937
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	11.68
95% Adjusted-CLT UCL (Chen-1995)	10.1	97.5% Chebyshev (MVUE) UCL	13.18
95% Modified-t UCL (Johnson-1978)	9.891	99% Chebyshev (MVUE) UCL	16.14

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	4.127	**Data do not follow a Discernable Distribution (0.05)**
Theta Star	2.007	
MLE of Mean	8.283	
MLE of Standard Deviation	4.077	
nu star	198.1	
Approximate Chi Square Value (.05)	166.5	
Adjusted Level of Significance	0.0392	
Adjusted Chi Square Value	164.5	
Anderson-Darling Test Statistic	1.427	
Anderson-Darling 5% Critical Value	0.747	
Kolmogorov-Smirnov Test Statistic	0.249	
Kolmogorov-Smirnov 5% Critical Value	0.178	
Data not Gamma Distributed at 5% Significance Level		

Assuming Gamma Distribution	
95% Approximate Gamma UCL	9.853
95% Adjusted Gamma UCL	9.975

Nonparametric Statistics	
95% CLT UCL	9.778
95% Jackknife UCL	9.841
95% Standard Bootstrap UCL	9.744
95% Bootstrap-t UCL	10.36
95% Hall's Bootstrap UCL	10.16
95% Percentile Bootstrap UCL	9.883
95% BCA Bootstrap UCL	10.04
95% Chebyshev(Mean, Sd) UCL	12.24
97.5% Chebyshev(Mean, Sd) UCL	13.96
99% Chebyshev(Mean, Sd) UCL	17.33

Potential UCL to Use	Use 95% Student's-t UCL 9.841
	or 95% Modified-t UCL 9.891

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Cobalt

General Statistics

Number of Valid Observations	24	Number of Distinct Observations	22

Raw Statistics		**Log-transformed Statistics**	
Minimum	3	Minimum of Log Data	1.099
Maximum	14.7	Maximum of Log Data	2.688
Mean	9.892	Mean of log Data	2.234
Median	10.4	SD of log Data	0.38
SD	2.938		
Std. Error of Mean	0.6		
Coefficient of Variation	0.297		
Skewness	-0.77		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.945	Shapiro Wilk Test Statistic	0.838
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data appear Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	10.92	95% H-UCL	11.65
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	13.47
95% Adjusted-CLT UCL (Chen-1995)	10.78	97.5% Chebyshev (MVUE) UCL	14.97
95% Modified-t UCL (Johnson-1978)	10.9	99% Chebyshev (MVUE) UCL	17.92

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	7.734	**Data appear Normal at 5% Significance Level**	
Theta Star	1.279		
MLE of Mean	9.892		
MLE of Standard Deviation	3.557		
nu star	371.2		
Approximate Chi Square Value (.05)	327.6	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0392	95% CLT UCL	10.88
Adjusted Chi Square Value	324.7	95% Jackknife UCL	10.92
		95% Standard Bootstrap UCL	10.84
Anderson-Darling Test Statistic	1.078	95% Bootstrap-t UCL	10.83
Anderson-Darling 5% Critical Value	0.745	95% Hall's Bootstrap UCL	10.82
Kolmogorov-Smirnov Test Statistic	0.194	95% Percentile Bootstrap UCL	10.83
Kolmogorov-Smirnov 5% Critical Value	0.178	95% BCA Bootstrap UCL	10.75
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	12.51
		97.5% Chebyshev(Mean, Sd) UCL	13.64
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	15.86
95% Approximate Gamma UCL	11.21		
95% Adjusted Gamma UCL	11.31		

Potential UCL to Use	Use 95% Student's-t UCL	10.92

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Note: For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Iron

General Statistics

Number of Valid Observations	24	Number of Distinct Observations	24

Raw Statistics		**Log-transformed Statistics**	
Minimum	6780	Minimum of Log Data	8.822
Maximum	41800	Maximum of Log Data	10.64
Mean	26099	Mean of log Data	10.11
Median	25650	SD of log Data	0.39
SD	8422		
Std. Error of Mean	1719		
Coefficient of Variation	0.323		
Skewness	-0.0624		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.979	Shapiro Wilk Test Statistic	0.887
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data appear Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	29045	95% H-UCL	30855
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	35748
95% Adjusted-CLT UCL (Chen-1995)	28903	97.5% Chebyshev (MVUE) UCL	39803
95% Modified-t UCL (Johnson-1978)	29042	99% Chebyshev (MVUE) UCL	47769

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	7.225	**Data appear Normal at 5% Significance Level**
Theta Star	3612	
MLE of Mean	26099	
MLE of Standard Deviation	9709	
nu star	346.8	
Approximate Chi Square Value (.05)	304.7	**Nonparametric Statistics**
Adjusted Level of Significance	0.0392	95% CLT UCL 28927
Adjusted Chi Square Value	301.9	95% Jackknife UCL 29045
		95% Standard Bootstrap UCL 28844
Anderson-Darling Test Statistic	0.369	95% Bootstrap-t UCL 29122
Anderson-Darling 5% Critical Value	0.745	95% Hall's Bootstrap UCL 28907
Kolmogorov-Smirnov Test Statistic	0.128	95% Percentile Bootstrap UCL 28903
Kolmogorov-Smirnov 5% Critical Value	0.178	95% BCA Bootstrap UCL 28813
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 33593
		97.5% Chebyshev(Mean, Sd) UCL 36835
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 43204
95% Approximate Gamma UCL	29710	
95% Adjusted Gamma UCL	29983	

Potential UCL to Use	Use 95% Student's-t UCL 29045

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Note: For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Manganese

General Statistics

Number of Valid Observations	24	Number of Distinct Observations	24

Raw Statistics		**Log-transformed Statistics**	
Minimum	191	Minimum of Log Data	5.252
Maximum	650	Maximum of Log Data	6.477
Mean	386.1	Mean of log Data	5.893
Median	360.5	SD of log Data	0.365
SD	141		
Std. Error of Mean	28.78		
Coefficient of Variation	0.365		
Skewness	0.579		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.923	Shapiro Wilk Test Statistic	0.957
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	435.4	95% H-UCL	446.6
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	514.4
95% Adjusted-CLT UCL (Chen-1995)	437.1	97.5% Chebyshev (MVUE) UCL	569.9
95% Modified-t UCL (Johnson-1978)	436	99% Chebyshev (MVUE) UCL	678.9

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	7.065	**Data appear Normal at 5% Significance Level**
Theta Star	54.65	
MLE of Mean	386.1	
MLE of Standard Deviation	145.3	
nu star	339.1	
Approximate Chi Square Value (.05)	297.4	**Nonparametric Statistics**
Adjusted Level of Significance	0.0392	95% CLT UCL 433.4
Adjusted Chi Square Value	294.7	95% Jackknife UCL 435.4
		95% Standard Bootstrap UCL 432.8
Anderson-Darling Test Statistic	0.402	95% Bootstrap-t UCL 441.9
Anderson-Darling 5% Critical Value	0.745	95% Hall's Bootstrap UCL 439
Kolmogorov-Smirnov Test Statistic	0.138	95% Percentile Bootstrap UCL 433.2
Kolmogorov-Smirnov 5% Critical Value	0.178	95% BCA Bootstrap UCL 436.5
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 511.6
		97.5% Chebyshev(Mean, Sd) UCL 565.8
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 672.5
95% Approximate Gamma UCL	440.2	
95% Adjusted Gamma UCL	444.3	

Potential UCL to Use Use 95% Student's-t UCL 435.4

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Thallium

General Statistics

Number of Valid Data	24	Number of Detected Data	23
Number of Distinct Detected Data	21	Number of Non-Detect Data	1
		Percent Non-Detects	4.17%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.0066	Minimum Detected	-5.021
Maximum Detected	0.8	Maximum Detected	-0.223
Mean of Detected	0.0605	Mean of Detected	-3.572
SD of Detected	0.162	SD of Detected	0.883
Minimum Non-Detect	1.2	Minimum Non-Detect	0.182
Maximum Non-Detect	1.2	Maximum Non-Detect	0.182

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.274	Shapiro Wilk Test Statistic	0.764
5% Shapiro Wilk Critical Value	0.914	5% Shapiro Wilk Critical Value	0.914
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.083	Mean	-3.444
SD	0.193	SD	1.066
95% DL/2 (t) UCL	0.15	95% H-Stat (DL/2) UCL	0.101
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-3.572
		SD in Log Scale	0.864
		Mean in Original Scale	0.0591
		SD in Original Scale	0.158
		95% t UCL	0.114
		95% Percentile Bootstrap UCL	0.123
		95% BCA Bootstrap UCL	0.157
		95% H-UCL	0.0625

Appendix C-3
ProUCL Output - Surface/Subsurface Soil at Former Sugar Mill
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	0.705
Theta Star	0.0858
nu star	32.43
A-D Test Statistic	4.003
5% A-D Critical Value	0.781
K-S Test Statistic	0.781
5% K-S Critical Value	0.188
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	0.0066
Maximum	0.8
Mean	0.0601
Median	0.0275
SD	0.158
k star	0.734
Theta star	0.0819
Nu star	35.22
AppChi2	22.64
95% Gamma Approximate UCL	0.0935
95% Adjusted Gamma UCL	0.0965

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only	
Data do not follow a Discernable Distribution (0.05)	

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.0605
SD	0.158
SE of Mean	0.0337
95% KM (t) UCL	0.118
95% KM (z) UCL	0.116
95% KM (jackknife) UCL	0.118
95% KM (bootstrap t) UCL	0.638
95% KM (BCA) UCL	0.127
95% KM (Percentile Bootstrap) UCL	0.127
95% KM (Chebyshev) UCL	0.207
97.5% KM (Chebyshev) UCL	0.271
99% KM (Chebyshev) UCL	0.396
Potential UCLs to Use	
95% KM (Chebyshev) UCL	0.207

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Vanadium

General Statistics

Number of Valid Observations	24	Number of Distinct Observations	24

Raw Statistics		**Log-transformed Statistics**	
Minimum	24.3	Minimum of Log Data	3.19
Maximum	192	Maximum of Log Data	5.257
Mean	84.3	Mean of log Data	4.352
Median	80	SD of log Data	0.434
SD	34.07		
Std. Error of Mean	6.954		
Coefficient of Variation	0.404		
Skewness	1.11		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.917	Shapiro Wilk Test Statistic	0.935
Shapiro Wilk Critical Value	0.916	Shapiro Wilk Critical Value	0.916
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	96.21	95% H-UCL	101.5
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	118.7
95% Adjusted-CLT UCL (Chen-1995)	97.42	97.5% Chebyshev (MVUE) UCL	133.3
95% Modified-t UCL (Johnson-1978)	96.48	99% Chebyshev (MVUE) UCL	162

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	5.49	**Data appear Normal at 5% Significance Level**
Theta Star	15.35	
MLE of Mean	84.3	
MLE of Standard Deviation	35.97	
nu star	263.5	
Approximate Chi Square Value (.05)	227	**Nonparametric Statistics**
Adjusted Level of Significance	0.0392	95% CLT UCL 95.73
Adjusted Chi Square Value	224.6	95% Jackknife UCL 96.21
		95% Standard Bootstrap UCL 95.39
Anderson-Darling Test Statistic	0.532	95% Bootstrap-t UCL 98.79
Anderson-Darling 5% Critical Value	0.746	95% Hall's Bootstrap UCL 102
Kolmogorov-Smirnov Test Statistic	0.145	95% Percentile Bootstrap UCL 95.25
Kolmogorov-Smirnov 5% Critical Value	0.178	95% BCA Bootstrap UCL 97.01
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 114.6
		97.5% Chebyshev(Mean, Sd) UCL 127.7
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 153.5
95% Approximate Gamma UCL	97.89	
95% Adjusted Gamma UCL	98.93	

Potential UCL to Use	Use 95% Student's-t UCL 96.21

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Appendix C-4
ProUCL Output - Surface/Subsurface Soil at Puerto Rico Beverage
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	SB-PRB.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Number of Valid Observations	20	Number of Distinct Observations	20

Raw Statistics

Minimum	7060
Maximum	37800
Mean	13551
Median	11150
SD	7369
Std. Error of Mean	1648
Coefficient of Variation	0.544
Skewness	2.078

Log-transformed Statistics

Minimum of Log Data	8.862
Maximum of Log Data	10.54
Mean of log Data	9.409
SD of log Data	0.446

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.78
Shapiro Wilk Critical Value	0.905

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.921
Shapiro Wilk Critical Value	0.905

Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	16400

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL (Chen-1995)	17080
95% Modified-t UCL (Johnson-1978)	16528

Assuming Lognormal Distribution

95% H-UCL	16469
95% Chebyshev (MVUE) UCL	19384
97.5% Chebyshev (MVUE) UCL	21977
99% Chebyshev (MVUE) UCL	27069

Gamma Distribution Test

k star (bias corrected)	4.191
Theta Star	3233
MLE of Mean	13551
MLE of Standard Deviation	6619
nu star	167.6
Approximate Chi Square Value (.05)	138.7
Adjusted Level of Significance	0.038
Adjusted Chi Square Value	136.6
Anderson-Darling Test Statistic	0.703
Anderson-Darling 5% Critical Value	0.745
Kolmogorov-Smirnov Test Statistic	0.158
Kolmogorov-Smirnov 5% Critical Value	0.194

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	16378
95% Adjusted Gamma UCL	16627

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	16261
95% Jackknife UCL	16400
95% Standard Bootstrap UCL	16171
95% Bootstrap-t UCL	17855
95% Hall's Bootstrap UCL	20021
95% Percentile Bootstrap UCL	16368
95% BCA Bootstrap UCL	16929
95% Chebyshev(Mean, Sd) UCL	20734
97.5% Chebyshev(Mean, Sd) UCL	23842
99% Chebyshev(Mean, Sd) UCL	29946

Potential UCL to Use

Use 95% Approximate Gamma UCL 16378

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Arsenic

General Statistics

Number of Valid Data	20	Number of Detected Data	4
Number of Distinct Detected Data	4	Number of Non-Detect Data	16
		Percent Non-Detects	80.00%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.27	Minimum Detected	-1.309
Maximum Detected	2.9	Maximum Detected	1.065
Mean of Detected	0.973	Mean of Detected	-0.582
SD of Detected	1.287	SD of Detected	1.116
Minimum Non-Detect	1.1	Minimum Non-Detect	0.0953
Maximum Non-Detect	1.5	Maximum Non-Detect	0.405

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	19
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	1
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	95.00%

Warning: There are only 4 Distinct Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.675	Shapiro Wilk Test Statistic	0.771
5% Shapiro Wilk Critical Value	0.748	5% Shapiro Wilk Critical Value	0.748
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.68	Mean	-0.522
SD	0.537	SD	0.456
95% DL/2 (t) UCL	0.887	95% H-Stat (DL/2) UCL	0.81
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-0.963
		SD in Log Scale	0.701
		Mean in Original Scale	0.516
		SD in Original Scale	0.597
		95% t UCL	0.747
		95% Percentile Bootstrap UCL	0.774
		95% BCA Bootstrap UCL	0.924
		95% H-UCL	0.699

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.426
Theta Star	2.282
nu star	3.409
A-D Test Statistic	0.708
5% A-D Critical Value	0.666
K-S Test Statistic	0.666
5% K-S Critical Value	0.402

Data follow Appr. Gamma Distribution at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	2.9
Mean	0.589
Median	0.301
SD	0.735
k star	0.217
Theta star	2.717
Nu star	8.673
AppChi2	3.131
95% Gamma Approximate UCL	1.632
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data Follow Appr. Gamma Distribution at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.459
SD	0.564
SE of Mean	0.151
95% KM (t) UCL	0.72
95% KM (z) UCL	0.708
95% KM (jackknife) UCL	0.702
95% KM (bootstrap t) UCL	1.2
95% KM (BCA) UCL	0.839
95% KM (Percentile Bootstrap) UCL	0.804
95% KM (Chebyshev) UCL	1.119
97.5% KM (Chebyshev) UCL	1.405
99% KM (Chebyshev) UCL	1.966

Potential UCLs to Use

95% KM (t) UCL	0.72

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Chromium

General Statistics

Number of Valid Observations	20	Number of Distinct Observations	18

Raw Statistics		**Log-transformed Statistics**	
Minimum	0.9	Minimum of Log Data	-0.105
Maximum	27.5	Maximum of Log Data	3.314
Mean	4.065	Mean of log Data	1.029
Median	2.45	SD of log Data	0.749
SD	5.703		
Std. Error of Mean	1.275		
Coefficient of Variation	1.403		
Skewness	4.014		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.46	Shapiro Wilk Test Statistic	0.907
Shapiro Wilk Critical Value	0.905	Shapiro Wilk Critical Value	0.905
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	6.27	95% H-UCL	5.499
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	6.502
95% Adjusted-CLT UCL (Chen-1995)	7.386	97.5% Chebyshev (MVUE) UCL	7.74
95% Modified-t UCL (Johnson-1978)	6.461	99% Chebyshev (MVUE) UCL	10.17

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	1.296	**Data Follow Appr. Gamma Distribution at 5% Significance Level**
Theta Star	3.138	
MLE of Mean	4.065	
MLE of Standard Deviation	3.571	
nu star	51.82	
Approximate Chi Square Value (.05)	36.29	**Nonparametric Statistics**
Adjusted Level of Significance	0.038	95% CLT UCL 6.163
Adjusted Chi Square Value	35.26	95% Jackknife UCL 6.27
		95% Standard Bootstrap UCL 6.063
Anderson-Darling Test Statistic	1.393	95% Bootstrap-t UCL 11.2
Anderson-Darling 5% Critical Value	0.758	95% Hall's Bootstrap UCL 13.94
Kolmogorov-Smirnov Test Statistic	0.188	95% Percentile Bootstrap UCL 6.635
Kolmogorov-Smirnov 5% Critical Value	0.197	95% BCA Bootstrap UCL 7.965
Data follow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 9.624
		97.5% Chebyshev(Mean, Sd) UCL 12.03
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 16.75
95% Approximate Gamma UCL	5.805	
95% Adjusted Gamma UCL	5.974	

Potential UCL to Use	Use 95% Approximate Gamma UCL 5.805

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Cobalt

General Statistics

Number of Valid Observations	20	Number of Distinct Observations	18

Raw Statistics		**Log-transformed Statistics**	
Minimum	2.1	Minimum of Log Data	0.742
Maximum	16.1	Maximum of Log Data	2.779
Mean	6.62	Mean of log Data	1.768
Median	6.05	SD of log Data	0.505
SD	3.535		
Std. Error of Mean	0.79		
Coefficient of Variation	0.534		
Skewness	1.32		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.881	Shapiro Wilk Test Statistic	0.983
Shapiro Wilk Critical Value	0.905	Shapiro Wilk Critical Value	0.905
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	7.987	95% H-UCL	8.41
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	9.978
95% Adjusted-CLT UCL (Chen-1995)	8.169	97.5% Chebyshev (MVUE) UCL	11.44
95% Modified-t UCL (Johnson-1978)	8.026	99% Chebyshev (MVUE) UCL	14.3

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	3.645	**Data appear Gamma Distributed at 5% Significance Level**	
Theta Star	1.816		
MLE of Mean	6.62		
MLE of Standard Deviation	3.467		
nu star	145.8		
Approximate Chi Square Value (.05)	118.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.038	95% CLT UCL	7.92
Adjusted Chi Square Value	117	95% Jackknife UCL	7.987
		95% Standard Bootstrap UCL	7.884
Anderson-Darling Test Statistic	0.349	95% Bootstrap-t UCL	8.383
Anderson-Darling 5% Critical Value	0.745	95% Hall's Bootstrap UCL	8.427
Kolmogorov-Smirnov Test Statistic	0.136	95% Percentile Bootstrap UCL	7.93
Kolmogorov-Smirnov 5% Critical Value	0.195	95% BCA Bootstrap UCL	8.165
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	10.07
		97.5% Chebyshev(Mean, Sd) UCL	11.56
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	14.48
95% Approximate Gamma UCL	8.118		
95% Adjusted Gamma UCL	8.251		

Potential UCL to Use		Use 95% Approximate Gamma UCL	8.118

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Iron

General Statistics

Number of Valid Observations	20	Number of Distinct Observations	18

Raw Statistics		**Log-transformed Statistics**	
Minimum	13200	Minimum of Log Data	9.488
Maximum	44700	Maximum of Log Data	10.71
Mean	24125	Mean of log Data	10.03
Median	20100	SD of log Data	0.364
SD	9362		
Std. Error of Mean	2093		
Coefficient of Variation	0.388		
Skewness	0.917		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.877	Shapiro Wilk Test Statistic	0.93
Shapiro Wilk Critical Value	0.905	Shapiro Wilk Critical Value	0.905
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	27745	95% H-UCL	28285
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	32754
95% Adjusted-CLT UCL (Chen-1995)	28027	97.5% Chebyshev (MVUE) UCL	36517
95% Modified-t UCL (Johnson-1978)	27816	99% Chebyshev (MVUE) UCL	43909

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	6.672	**Data Follow Appr. Gamma Distribution at 5% Significance Level**
Theta Star	3616	
MLE of Mean	24125	
MLE of Standard Deviation	9340	
nu star	266.9	
Approximate Chi Square Value (.05)	230	**Nonparametric Statistics**
Adjusted Level of Significance	0.038	95% CLT UCL 27568
Adjusted Chi Square Value	227.3	95% Jackknife UCL 27745
		95% Standard Bootstrap UCL 27382
Anderson-Darling Test Statistic	0.737	95% Bootstrap-t UCL 28554
Anderson-Darling 5% Critical Value	0.743	95% Hall's Bootstrap UCL 27949
Kolmogorov-Smirnov Test Statistic	0.196	95% Percentile Bootstrap UCL 27455
Kolmogorov-Smirnov 5% Critical Value	0.194	95% BCA Bootstrap UCL 28240
Data follow Appr. Gamma Distribution at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 33249
		97.5% Chebyshev(Mean, Sd) UCL 37198
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 44953
95% Approximate Gamma UCL	27988	
95% Adjusted Gamma UCL	28320	

Potential UCL to Use	Use 95% Approximate Gamma UCL	27988

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Manganese

General Statistics

Number of Valid Observations	20	Number of Distinct Observations	19

Raw Statistics		**Log-transformed Statistics**	
Minimum	89.6	Minimum of Log Data	4.495
Maximum	474	Maximum of Log Data	6.161
Mean	285.1	Mean of log Data	5.569
Median	287.5	SD of log Data	0.447
SD	108.3		
Std. Error of Mean	24.23		
Coefficient of Variation	0.38		
Skewness	-0.107		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.97	Shapiro Wilk Test Statistic	0.926
Shapiro Wilk Critical Value	0.905	Shapiro Wilk Critical Value	0.905
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	327	95% H-UCL	354.4
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	417.2
95% Adjusted-CLT UCL (Chen-1995)	324.3	97.5% Chebyshev (MVUE) UCL	473.1
95% Modified-t UCL (Johnson-1978)	326.9	99% Chebyshev (MVUE) UCL	582.9

Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	5.235	**Data appear Normal at 5% Significance Level**	
Theta Star	54.45		
MLE of Mean	285.1		
MLE of Standard Deviation	124.6		
nu star	209.4		
Approximate Chi Square Value (.05)	176.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.038	95% CLT UCL	324.9
Adjusted Chi Square Value	174.6	95% Jackknife UCL	327
		95% Standard Bootstrap UCL	324
Anderson-Darling Test Statistic	0.445	95% Bootstrap-t UCL	326.2
Anderson-Darling 5% Critical Value	0.744	95% Hall's Bootstrap UCL	323.8
Kolmogorov-Smirnov Test Statistic	0.149	95% Percentile Bootstrap UCL	322.5
Kolmogorov-Smirnov 5% Critical Value	0.194	95% BCA Bootstrap UCL	322.3
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	390.7
		97.5% Chebyshev(Mean, Sd) UCL	436.4
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	526.1
95% Approximate Gamma UCL	337.4		
95% Adjusted Gamma UCL	342		

Potential UCL to Use	Use 95% Student's-t UCL 327

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Note: For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Vanadium

General Statistics

Number of Valid Observations	20	Number of Distinct Observations	20

Raw Statistics		**Log-transformed Statistics**	
Minimum	31.9	Minimum of Log Data	3.463
Maximum	162	Maximum of Log Data	5.088
Mean	69.29	Mean of log Data	4.109
Median	54.35	SD of log Data	0.513
SD	37.72		
Std. Error of Mean	8.435		
Coefficient of Variation	0.544		
Skewness	1.047		

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.868	Shapiro Wilk Test Statistic	0.926
Shapiro Wilk Critical Value	0.905	Shapiro Wilk Critical Value	0.905
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	83.88	95% H-UCL	88.22
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	104.8
95% Adjusted-CLT UCL (Chen-1995)	85.27	97.5% Chebyshev (MVUE) UCL	120.2
95% Modified-t UCL (Johnson-1978)	84.2	99% Chebyshev (MVUE) UCL	150.7

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	3.46	**Data appear Gamma Distributed at 5% Significance Level**
Theta Star	20.03	
MLE of Mean	69.29	
MLE of Standard Deviation	37.25	
nu star	138.4	
Approximate Chi Square Value (.05)	112.2	**Nonparametric Statistics**
Adjusted Level of Significance	0.038	95% CLT UCL 83.16
Adjusted Chi Square Value	110.4	95% Jackknife UCL 83.88
		95% Standard Bootstrap UCL 82.63
Anderson-Darling Test Statistic	0.629	95% Bootstrap-t UCL 86.56
Anderson-Darling 5% Critical Value	0.746	95% Hall's Bootstrap UCL 85.78
Kolmogorov-Smirnov Test Statistic	0.162	95% Percentile Bootstrap UCL 83.6
Kolmogorov-Smirnov 5% Critical Value	0.195	95% BCA Bootstrap UCL 85.15
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 106.1
		97.5% Chebyshev(Mean, Sd) UCL 122
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 153.2
95% Approximate Gamma UCL	85.46	
95% Adjusted Gamma UCL	86.9	

Potential UCL to Use		Use 95% Approximate Gamma UCL	85.46

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Appendix C-5
ProUCL Output - Groundwater
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	GW_a.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

cis-1,2-Dichloroethene

General Statistics

Number of Valid Data	35	Number of Detected Data	16
Number of Distinct Detected Data	15	Number of Non-Detect Data	19
		Percent Non-Detects	54.29%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.38	Minimum Detected	-0.968
Maximum Detected	300	Maximum Detected	5.704
Mean of Detected	66.63	Mean of Detected	2.181
SD of Detected	112.3	SD of Detected	2.331
Minimum Non-Detect	0.5	Minimum Non-Detect	-0.693
Maximum Non-Detect	0.5	Maximum Non-Detect	-0.693

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.623	Shapiro Wilk Test Statistic	0.913
5% Shapiro Wilk Critical Value	0.887	5% Shapiro Wilk Critical Value	0.887
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	30.6	Mean	0.244
SD	81.77	SD	2.376
95% DL/2 (t) UCL	53.97	95% H-Stat (DL/2) UCL	133.8
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-0.69
		SD in Log Scale	3.438
		Mean in Original Scale	30.55
		SD in Original Scale	81.79
		95% t UCL	53.92
		95% Percentile Bootstrap UCL	55.83
		95% BCA Bootstrap UCL	63.96
		95% H-UCL	7352

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.314
Theta Star	212.1
nu star	10.05
A-D Test Statistic	1.014
5% A-D Critical Value	0.83
K-S Test Statistic	0.83
5% K-S Critical Value	0.232

Data follow Appr. Gamma Distribution at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	300
Mean	30.46
Median	0.000001
SD	81.82
k star	0.0955
Theta star	318.8
Nu star	6.688
AppChi2	2.001
95% Gamma Approximate UCL	101.8
95% Adjusted Gamma UCL	108.3

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data Follow Appr. Gamma Distribution at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	30.67
SD	80.56
SE of Mean	14.06
95% KM (t) UCL	54.45
95% KM (z) UCL	53.8
95% KM (jackknife) UCL	53.94
95% KM (bootstrap t) UCL	67.94
95% KM (BCA) UCL	55.8
95% KM (Percentile Bootstrap) UCL	56.25
95% KM (Chebyshev) UCL	91.97
97.5% KM (Chebyshev) UCL	118.5
99% KM (Chebyshev) UCL	170.6

Potential UCLs to Use

95% KM (t) UCL	54.45

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Tetrachloroethene

General Statistics

Number of Valid Data	35	Number of Detected Data	9
Number of Distinct Detected Data	8	Number of Non-Detect Data	26
		Percent Non-Detects	74.29%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.1	Minimum Detected	-2.303
Maximum Detected	8.5	Maximum Detected	2.14
Mean of Detected	1.736	Mean of Detected	-0.459
SD of Detected	2.722	SD of Detected	1.524
Minimum Non-Detect	0.2	Minimum Non-Detect	-1.609
Maximum Non-Detect	0.2	Maximum Non-Detect	-1.609

Warning: There are only 9 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.666	Shapiro Wilk Test Statistic	0.931
5% Shapiro Wilk Critical Value	0.829	5% Shapiro Wilk Critical Value	0.829
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.521	Mean	-1.829
SD	1.506	SD	1.102
95% DL/2 (t) UCL	0.951	95% H-Stat (DL/2) UCL	0.48
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-2.063
		SD in Log Scale	1.565
		Mean in Original Scale	0.538
		SD in Original Scale	1.505
		95% t UCL	0.968
		95% Percentile Bootstrap UCL	0.978
		95% BCA Bootstrap UCL	1.278
		95% H-UCL	1.027

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.481
Theta Star	3.61
nu star	8.654
A-D Test Statistic	0.517
5% A-D Critical Value	0.762
K-S Test Statistic	0.762
5% K-S Critical Value	0.292

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	8.5
Mean	0.585
Median	0.000001
SD	1.524
k star	0.121
Theta star	4.845
Nu star	8.449
AppChi2	2.998
95% Gamma Approximate UCL	1.648
95% Adjusted Gamma UCL	1.737

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.543
SD	1.479
SE of Mean	0.266
95% KM (t) UCL	0.992
95% KM (z) UCL	0.98
95% KM (jackknife) UCL	0.975
95% KM (bootstrap t) UCL	1.914
95% KM (BCA) UCL	1.114
95% KM (Percentile Bootstrap) UCL	1.049
95% KM (Chebyshev) UCL	1.701
97.5% KM (Chebyshev) UCL	2.202
99% KM (Chebyshev) UCL	3.186

Potential UCLs to Use

95% KM (t) UCL	0.992

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

trans-1,2-Dichloroethene

General Statistics

Number of Valid Data	35	Number of Detected Data	4
Number of Distinct Detected Data	4	Number of Non-Detect Data	31
		Percent Non-Detects	88.57%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.99	Minimum Detected	-0.0101
Maximum Detected	13	Maximum Detected	2.565
Mean of Detected	5.773	Mean of Detected	1.233
SD of Detected	5.714	SD of Detected	1.262
Minimum Non-Detect	0.5	Minimum Non-Detect	-0.693
Maximum Non-Detect	0.5	Maximum Non-Detect	-0.693

Warning: There are only 4 Distinct Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.885	Shapiro Wilk Test Statistic	0.885
5% Shapiro Wilk Critical Value	0.748	5% Shapiro Wilk Critical Value	0.748
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.881	Mean	-1.087
SD	2.461	SD	0.925
95% DL/2 (t) UCL	1.585	95% H-Stat (DL/2) UCL	0.753
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-5.528
		SD in Log Scale	3.943
		Mean in Original Scale	0.688
		SD in Original Scale	2.514
		95% t UCL	1.407
		95% Percentile Bootstrap UCL	1.438
		95% BCA Bootstrap UCL	1.793
		95% H-UCL	1141

Appendix C-5
ProUCL Output - Groundwater
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.441
Theta Star	13.08
nu star	3.53
A-D Test Statistic	0.395
5% A-D Critical Value	0.666
K-S Test Statistic	0.666
5% K-S Critical Value	0.402

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	13
Mean	0.66
Median	0.000001
SD	2.52
k star	0.0851
Theta star	7.753
Nu star	5.957
AppChi2	1.618
95% Gamma Approximate UCL	2.429
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	1.537
SD	2.261
SE of Mean	0.441
95% KM (t) UCL	2.283
95% KM (z) UCL	2.263
95% KM (jackknife) UCL	2.09
95% KM (bootstrap t) UCL	2.235
95% KM (BCA) UCL	13
95% KM (Percentile Bootstrap) UCL	8.003
95% KM (Chebyshev) UCL	3.46
97.5% KM (Chebyshev) UCL	4.293
99% KM (Chebyshev) UCL	5.928

Potential UCLs to Use

95% KM (t) UCL	2.283
95% KM (Percentile Bootstrap) UCL	8.003

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Trichloroethene

General Statistics

Number of Valid Data	35	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	28
		Percent Non-Detects	80.00%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.29	Minimum Detected	-1.238
Maximum Detected	1.9	Maximum Detected	0.642
Mean of Detected	0.783	Mean of Detected	-0.515
SD of Detected	0.67	SD of Detected	0.753
Minimum Non-Detect	0.5	Minimum Non-Detect	-0.693
Maximum Non-Detect	2.5	Maximum Non-Detect	0.916

Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	35
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	0
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	100.00%

Warning: There are only 7 Detected Values in this data

Note: It should be noted that even though bootstrap may be performed on this data set the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.723	Shapiro Wilk Test Statistic	0.809
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.385	Mean	-1.166
SD	0.385	SD	0.532
95% DL/2 (t) UCL	0.495	95% H-Stat (DL/2) UCL	0.429
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-0.902
		SD in Log Scale	0.553
		Mean in Original Scale	0.481
		SD in Original Scale	0.357
		95% t UCL	0.583
		95% Percentile Bootstrap UCL	0.584
		95% BCA Bootstrap UCL	0.631
		95% H-UCL	0.571

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.239
Theta Star	0.632
nu star	17.34
A-D Test Statistic	0.879
5% A-D Critical Value	0.715
K-S Test Statistic	0.715
5% K-S Critical Value	0.315

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	1.9
Mean	0.547
Median	0.483
SD	0.446
k star	0.335
Theta star	1.632
Nu star	23.45
AppChi2	13.43
95% Gamma Approximate UCL	0.955
95% Adjusted Gamma UCL	0.981

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Lognormal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.453
SD	0.331
SE of Mean	0.0654
95% KM (t) UCL	0.564
95% KM (z) UCL	0.561
95% KM (jackknife) UCL	0.562
95% KM (bootstrap t) UCL	0.704
95% KM (BCA) UCL	0.567
95% KM (Percentile Bootstrap) UCL	0.572
95% KM (Chebyshev) UCL	0.738
97.5% KM (Chebyshev) UCL	0.861
99% KM (Chebyshev) UCL	1.103

Potential UCLs to Use

95% KM (t) UCL	0.564
95% KM (% Bootstrap) UCL	0.572

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Vinyl Chloride

General Statistics

Number of Valid Data	35	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	32
		Percent Non-Detects	91.43%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.22	Minimum Detected	-1.514
Maximum Detected	0.73	Maximum Detected	-0.315
Mean of Detected	0.53	Mean of Detected	-0.758
SD of Detected	0.272	SD of Detected	0.658
Minimum Non-Detect	0.2	Minimum Non-Detect	-1.609
Maximum Non-Detect	0.2	Maximum Non-Detect	-1.609

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.878	Shapiro Wilk Test Statistic	0.831
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.137	Mean	-2.17
SD	0.139	SD	0.467
95% DL/2 (t) UCL	0.177	95% H-Stat (DL/2) UCL	0.148
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-4.616
		SD in Log Scale	2.086
		Mean in Original Scale	0.0658
		SD in Original Scale	0.162
		95% t UCL	0.112
		95% Percentile Bootstrap UCL	0.114
		95% BCA Bootstrap UCL	0.135
		95% H-UCL	0.368

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.247
SD	0.108
SE of Mean	0.0225
95% KM (t) UCL	0.285
95% KM (z) UCL	0.284
95% KM (jackknife) UCL	0.514
95% KM (bootstrap t) UCL	0.263
95% KM (BCA) UCL	0.73
95% KM (Percentile Bootstrap) UCL	0.73
95% KM (Chebyshev) UCL	0.344
97.5% KM (Chebyshev) UCL	0.387
99% KM (Chebyshev) UCL	0.47

Potential UCLs to Use

95% KM (t) UCL	0.285
95% KM (Percentile Bootstrap) UCL	0.73

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Aluminum

General Statistics

Number of Valid Data	31	Number of Detected Data	22
Number of Distinct Detected Data	20	Number of Non-Detect Data	9
Number of Missing Values	4	Percent Non-Detects	29.03%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	48.2	Minimum Detected	3.875
Maximum Detected	8190	Maximum Detected	9.011
Mean of Detected	540.8	Mean of Detected	5.127
SD of Detected	1714	SD of Detected	1.087
Minimum Non-Detect	20	Minimum Non-Detect	2.996
Maximum Non-Detect	20	Maximum Non-Detect	2.996

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.277	Shapiro Wilk Test Statistic	0.774
5% Shapiro Wilk Critical Value	0.911	5% Shapiro Wilk Critical Value	0.911
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	386.7	Mean	4.307
SD	1455	SD	1.589
95% DL/2 (t) UCL	830.2	95% H-Stat (DL/2) UCL	664.3
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	4.432
		SD in Log Scale	1.466
		Mean in Original Scale	389
		SD in Original Scale	1454
		95% t UCL	832.3
		95% Percentile Bootstrap UCL	913.1
		95% BCA Bootstrap UCL	1184
		95% H-UCL	554.2

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.495
Theta Star	1092
nu star	21.79
A-D Test Statistic	3.989
5% A-D Critical Value	0.801
K-S Test Statistic	0.801
5% K-S Critical Value	0.195

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	8190
Mean	383.8
Median	122
SD	1456
k star	0.134
Theta star	2860
Nu star	8.32
AppChi2	2.922
95% Gamma Approximate UCL	1093
95% Adjusted Gamma UCL	1163

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	397.8
SD	1429
SE of Mean	262.6
95% KM (t) UCL	843.5
95% KM (z) UCL	829.7
95% KM (jackknife) UCL	839.6
95% KM (bootstrap t) UCL	4965
95% KM (BCA) UCL	929.6
95% KM (Percentile Bootstrap) UCL	914.6
95% KM (Chebyshev) UCL	1542
97.5% KM (Chebyshev) UCL	2038
99% KM (Chebyshev) UCL	3011

Potential UCLs to Use

97.5% KM (Chebyshev) UCL	2038

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Arsenic

General Statistics

Number of Valid Data	31	Number of Detected Data	16
Number of Distinct Detected Data	13	Number of Non-Detect Data	15
Number of Missing Values	4	Percent Non-Detects	48.39%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.41	Minimum Detected	-0.892
Maximum Detected	7.2	Maximum Detected	1.974
Mean of Detected	5.202	Mean of Detected	1.432
SD of Detected	2.177	SD of Detected	0.89
Minimum Non-Detect	1	Minimum Non-Detect	0
Maximum Non-Detect	1	Maximum Non-Detect	0

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.801	Shapiro Wilk Test Statistic	0.608
5% Shapiro Wilk Critical Value	0.887	5% Shapiro Wilk Critical Value	0.887
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	2.927	Mean	0.404
SD	2.842	SD	1.25
95% DL/2 (t) UCL	3.793	95% H-Stat (DL/2) UCL	6.103
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	5.879	Mean in Log Scale	0.725
SD	1.19	SD in Log Scale	1.055
95% MLE (t) UCL	6.241	Mean in Original Scale	3.229
95% MLE (Tiku) UCL	6.418	SD in Original Scale	2.61
		95% t UCL	4.024
		95% Percentile Bootstrap UCL	4.065
		95% BCA Bootstrap UCL	4.071
		95% H UCL	5.812

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	2.037
Theta Star	2.554
nu star	65.18
A-D Test Statistic	2.266
5% A-D Critical Value	0.748
K-S Test Statistic	0.748
5% K-S Critical Value	0.217

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	7.2
Mean	3.252
Median	3.139
SD	2.71
k star	0.238
Theta star	13.68
Nu star	14.74
AppChi2	7.083
95% Gamma Approximate UCL	6.769
95% Adjusted Gamma UCL	7.062

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	2.91
SD	2.811
SE of Mean	0.522
95% KM (t) UCL	3.795
95% KM (z) UCL	3.768
95% KM (jackknife) UCL	3.783
95% KM (bootstrap t) UCL	3.76
95% KM (BCA) UCL	4.958
95% KM (Percentile Bootstrap) UCL	4.861
95% KM (Chebyshev) UCL	5.184
97.5% KM (Chebyshev) UCL	6.168
99% KM (Chebyshev) UCL	8.101

Potential UCLs to Use

95% KM (t) UCL	3.795
95% KM (% Bootstrap) UCL	4.861

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Barium

General Statistics

Number of Valid Observations	31	Number of Distinct Observations	28
Number of Missing Values	4		

Raw Statistics		Log-transformed Statistics	
Minimum	27.8	Minimum of Log Data	3.325
Maximum	346	Maximum of Log Data	5.846
Mean	175.7	Mean of log Data	4.991
Median	154	SD of log Data	0.678
SD	91.41		
Std. Error of Mean	16.42		
Coefficient of Variation	0.52		
Skewness	0.259		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.939	Shapiro Wilk Test Statistic	0.878
Shapiro Wilk Critical Value	0.929	Shapiro Wilk Critical Value	0.929
Data appear Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	203.6	95% H-UCL	239.5
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	288.4
95% Adjusted-CLT UCL (Chen-1995)	203.5	97.5% Chebyshev (MVUE) UCL	333.8
95% Modified-t UCL (Johnson-1978)	203.7	99% Chebyshev (MVUE) UCL	422.9

Gamma Distribution Test		Data Distribution	
k star (bias corrected)	2.708	**Data appear Normal at 5% Significance Level**	
Theta Star	64.89		
MLE of Mean	175.7		
MLE of Standard Deviation	106.8		
nu star	167.9		
Approximate Chi Square Value (.05)	138.9	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0413	95% CLT UCL	202.7
Adjusted Chi Square Value	137.5	95% Jackknife UCL	203.6
		95% Standard Bootstrap UCL	202.4
Anderson-Darling Test Statistic	0.668	95% Bootstrap-t UCL	205.4
Anderson-Darling 5% Critical Value	0.753	95% Hall's Bootstrap UCL	203.7
Kolmogorov-Smirnov Test Statistic	0.126	95% Percentile Bootstrap UCL	201.8
Kolmogorov-Smirnov 5% Critical Value	0.159	95% BCA Bootstrap UCL	205
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	247.3
		97.5% Chebyshev(Mean, Sd) UCL	278.3
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	339.1
95% Approximate Gamma UCL	212.4		
95% Adjusted Gamma UCL	214.6		

Potential UCL to Use	Use 95% Student's-t UCL 203.6

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Chromium

General Statistics

Number of Valid Data	17	Number of Detected Data	6
Number of Distinct Detected Data	6	Number of Non-Detect Data	11
Number of Missing Values	18	Percent Non-Detects	64.71%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	2.2	Minimum Detected	0.788
Maximum Detected	33.4	Maximum Detected	3.509
Mean of Detected	9.767	Mean of Detected	1.767
SD of Detected	12.11	SD of Detected	1.041
Minimum Non-Detect	2	Minimum Non-Detect	0.693
Maximum Non-Detect	2	Maximum Non-Detect	0.693

Warning: There are only 6 Detected Values in this data

Note: It should be noted that even though bootstrap may be performed on this data set the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.705	Shapiro Wilk Test Statistic	0.89
5% Shapiro Wilk Critical Value	0.788	5% Shapiro Wilk Critical Value	0.788
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	4.094	Mean	0.624
SD	8.029	SD	1.047
95% DL/2 (t) UCL	7.494	95% H-Stat (DL/2) UCL	6.614
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-0.674
		SD in Log Scale	2.251
		Mean in Original Scale	3.623
		SD in Original Scale	8.231
		95% t UCL	7.108
		95% Percentile Bootstrap UCL	7.127
		95% BCA Bootstrap UCL	8.975
		95% H-UCL	98.63

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.668
Theta Star	14.61
nu star	8.021
A-D Test Statistic	0.557
5% A-D Critical Value	0.713
K-S Test Statistic	0.713
5% K-S Critical Value	0.34

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	33.4
Mean	3.447
Median	0.000001
SD	8.304
k star	0.11
Theta star	31.2
Nu star	3.756
AppChi2	0.628
95% Gamma Approximate UCL	20.62
95% Adjusted Gamma UCL	25.29

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	4.871
SD	7.496
SE of Mean	1.992
95% KM (t) UCL	8.348
95% KM (z) UCL	8.147
95% KM (jackknife) UCL	7.996
95% KM (bootstrap t) UCL	27.38
95% KM (BCA) UCL	9.959
95% KM (Percentile Bootstrap) UCL	8.676
95% KM (Chebyshev) UCL	13.55
97.5% KM (Chebyshev) UCL	17.31
99% KM (Chebyshev) UCL	24.69

Potential UCLs to Use

95% KM (t) UCL	8.348

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Cobalt

General Statistics

Number of Valid Data	31	Number of Detected Data	13
Number of Distinct Detected Data	13	Number of Non-Detect Data	18
Number of Missing Values	4	Percent Non-Detects	58.06%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.12	Minimum Detected	-2.12
Maximum Detected	6.5	Maximum Detected	1.872
Mean of Detected	1.164	Mean of Detected	-0.489
SD of Detected	1.695	SD of Detected	1.144
Minimum Non-Detect	1	Minimum Non-Detect	0
Maximum Non-Detect	1	Maximum Non-Detect	0

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.601	Shapiro Wilk Test Statistic	0.962
5% Shapiro Wilk Critical Value	0.866	5% Shapiro Wilk Critical Value	0.866
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.778	Mean	-0.608
SD	1.123	SD	0.731
95% DL/2 (t) UCL	1.121	95% H-Stat (DL/2) UCL	0.946
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	-0.915
		SD in Log Scale	1.003
		Mean in Original Scale	0.709
		SD in Original Scale	1.159
		95% t UCL	1.063
		95% Percentile Bootstrap UCL	1.077
		95% BCA Bootstrap UCL	1.38
		95% H-UCL	1.034

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.752
Theta Star	1.547
nu star	19.56
A-D Test Statistic	0.49
5% A-D Critical Value	0.762
K-S Test Statistic	0.762
5% K-S Critical Value	0.244

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	6.5
Mean	0.827
Median	0.473
SD	1.205
k star	0.246
Theta star	3.366
Nu star	15.24
AppChi2	7.426
95% Gamma Approximate UCL	1.697
95% Adjusted Gamma UCL	1.769

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.701
SD	1.137
SE of Mean	0.22
95% KM (t) UCL	1.074
95% KM (z) UCL	1.062
95% KM (jackknife) UCL	1.068
95% KM (bootstrap t) UCL	1.504
95% KM (BCA) UCL	1.116
95% KM (Percentile Bootstrap) UCL	1.098
95% KM (Chebyshev) UCL	1.658
97.5% KM (Chebyshev) UCL	2.073
99% KM (Chebyshev) UCL	2.887

Potential UCLs to Use

95% KM (t) UCL	1.074

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Copper

General Statistics

Number of Valid Data	31	Number of Detected Data	23
Number of Distinct Detected Data	21	Number of Non-Detect Data	8
Number of Missing Values	4	Percent Non-Detects	25.81%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.45	Minimum Detected	-0.799
Maximum Detected	211	Maximum Detected	5.352
Mean of Detected	12.42	Mean of Detected	0.726
SD of Detected	43.87	SD of Detected	1.389
Minimum Non-Detect	2	Minimum Non-Detect	0.693
Maximum Non-Detect	2	Maximum Non-Detect	0.693

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.286	Shapiro Wilk Test Statistic	0.79
5% Shapiro Wilk Critical Value	0.914	5% Shapiro Wilk Critical Value	0.914
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	9.476	Mean	0.539
SD	37.91	SD	1.233
95% DL/2 (t) UCL	21.03	95% H-Stat (DL/2) UCL	6.751
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	0.511
		SD in Log Scale	1.293
		Mean in Original Scale	9.501
		SD in Original Scale	37.9
		95% t UCL	21.06
		95% Percentile Bootstrap UCL	22.81
		95% BCA Bootstrap UCL	29.92
		95% H-UCL	7.441

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.352
Theta Star	35.31
nu star	16.19
A-D Test Statistic	4.268
5% A-D Critical Value	0.833
K-S Test Statistic	0.833
5% K-S Critical Value	0.195

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	211
Mean	9.467
Median	1.115
SD	37.93
k star	0.179
Theta star	52.96
Nu star	11.08
AppChi2	4.629
95% Gamma Approximate UCL	22.66
95% Adjusted Gamma UCL	23.85

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	9.465
SD	37.29
SE of Mean	6.849
95% KM (t) UCL	21.09
95% KM (z) UCL	20.73
95% KM (jackknife) UCL	21.02
95% KM (bootstrap t) UCL	240.1
95% KM (BCA) UCL	22.61
95% KM (Percentile Bootstrap) UCL	22.81
95% KM (Chebyshev) UCL	39.32
97.5% KM (Chebyshev) UCL	52.24
99% KM (Chebyshev) UCL	77.61

Potential UCLs to Use

97.5% KM (Chebyshev) UCL	52.24

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Iron

General Statistics

Number of Valid Data	31	Number of Detected Data	28
Number of Distinct Detected Data	28	Number of Non-Detect Data	3
Number of Missing Values	4	Percent Non-Detects	9.68%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	28	Minimum Detected	3.332
Maximum Detected	16600	Maximum Detected	9.717
Mean of Detected	1750	Mean of Detected	5.733
SD of Detected	3854	SD of Detected	1.843
Minimum Non-Detect	200	Minimum Non-Detect	5.298
Maximum Non-Detect	200	Maximum Non-Detect	5.298

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.507	Shapiro Wilk Test Statistic	0.907
5% Shapiro Wilk Critical Value	0.924	5% Shapiro Wilk Critical Value	0.924
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	1590	Mean	5.623
SD	3690	SD	1.781
95% DL/2 (t) UCL	2715	95% H-Stat (DL/2) UCL	4193
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	5.591
		SD in Log Scale	1.814
		Mean in Original Scale	1589
		SD in Original Scale	3691
		95% t UCL	2714
		95% Percentile Bootstrap UCL	2736
		95% BCA Bootstrap UCL	3194
		95% H-UCL	4480

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	0.365
Theta Star	4795
nu star	20.44
A-D Test Statistic	2.173
5% A-D Critical Value	0.836
K-S Test Statistic	0.836
5% K-S Critical Value	0.178

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	16600
Mean	1581
Median	120
SD	3694
k star	0.209
Theta star	7563
Nu star	12.96
AppChi2	5.864
95% Gamma Approximate UCL	3493
95% Adjusted Gamma UCL	3658

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	1587
SD	3631
SE of Mean	664.2
95% KM (t) UCL	2714
95% KM (z) UCL	2680
95% KM (jackknife) UCL	2712
95% KM (bootstrap t) UCL	3992
95% KM (BCA) UCL	2826
95% KM (Percentile Bootstrap) UCL	2790
95% KM (Chebyshev) UCL	4482
97.5% KM (Chebyshev) UCL	5735
99% KM (Chebyshev) UCL	8196

Potential UCLs to Use

99% KM (Chebyshev) UCL	8196

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Manganese

General Statistics

Number of Valid Observations	31	Number of Distinct Observations	31
Number of Missing Values	4		

Raw Statistics		Log-transformed Statistics	
Minimum	0.62	Minimum of Log Data	-0.478
Maximum	2340	Maximum of Log Data	7.758
Mean	228.5	Mean of log Data	3.759
Median	59.2	SD of log Data	2.207
SD	483.7		
Std. Error of Mean	86.87		
Coefficient of Variation	2.117		
Skewness	3.562		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.499	Shapiro Wilk Test Statistic	0.955
Shapiro Wilk Critical Value	0.929	Shapiro Wilk Critical Value	0.929
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	375.9	95% H-UCL	2583
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	1316
95% Adjusted-CLT UCL (Chen-1995)	430.7	97.5% Chebyshev (MVUE) UCL	1717
95% Modified-t UCL (Johnson-1978)	385.2	99% Chebyshev (MVUE) UCL	2504

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.378	**Data appear Gamma Distributed at 5% Significance Level**
Theta Star	604.9	
MLE of Mean	228.5	
MLE of Standard Deviation	371.7	
nu star	23.42	
Approximate Chi Square Value (.05)	13.41	
Adjusted Level of Significance	0.0413	
Adjusted Chi Square Value	12.98	
Anderson-Darling Test Statistic	0.553	
Anderson-Darling 5% Critical Value	0.833	
Kolmogorov-Smirnov Test Statistic	0.126	
Kolmogorov-Smirnov 5% Critical Value	0.169	
Data appear Gamma Distributed at 5% Significance Level		

Nonparametric Statistics	
95% CLT UCL	371.4
95% Jackknife UCL	375.9
95% Standard Bootstrap UCL	365.8
95% Bootstrap-t UCL	685.5
95% Hall's Bootstrap UCL	1012
95% Percentile Bootstrap UCL	386.7
95% BCA Bootstrap UCL	434.4
95% Chebyshev(Mean, Sd) UCL	607.1
97.5% Chebyshev(Mean, Sd) UCL	771
99% Chebyshev(Mean, Sd) UCL	1093

Assuming Gamma Distribution

95% Approximate Gamma UCL	399.1
95% Adjusted Gamma UCL	412

Potential UCL to Use	
Use 95% Adjusted Gamma UCL	412

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Vanadium

General Statistics

Number of Valid Data	31	Number of Detected Data	26
Number of Distinct Detected Data	25	Number of Non-Detect Data	5
Number of Missing Values	4	Percent Non-Detects	16.13%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	0.72	Minimum Detected	-0.329
Maximum Detected	68.2	Maximum Detected	4.222
Mean of Detected	14.44	Mean of Detected	2.316
SD of Detected	13.2	SD of Detected	0.946
Minimum Non-Detect	5	Minimum Non-Detect	1.609
Maximum Non-Detect	5	Maximum Non-Detect	1.609

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.734	Shapiro Wilk Test Statistic	0.941
5% Shapiro Wilk Critical Value	0.92	5% Shapiro Wilk Critical Value	0.92
Data not Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	12.51	Mean	2.09
SD	12.85	SD	1.01
95% DL/2 (t) UCL	16.43	95% H-Stat (DL/2) UCL	21.09
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	10.17	Mean in Log Scale	2.08
SD	15.53	SD in Log Scale	1.033
95% MLE (t) UCL	14.91	Mean in Original Scale	12.51
95% MLE (Tiku) UCL	15.11	SD in Original Scale	12.85
		95% t UCL	16.43
		95% Percentile Bootstrap UCL	16.57
		95% BCA Bootstrap UCL	17.69
		95% H UCL	21.73

Appendix C-5
ProUCL Output - Groundwater
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	1.406
Theta Star	10.27
nu star	73.12
A-D Test Statistic	0.334
5% A-D Critical Value	0.761
K-S Test Statistic	0.761
5% K-S Critical Value	0.174

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	0.000001
Maximum	68.2
Mean	12.18
Median	10.2
SD	13.14
k star	0.333
Theta star	36.63
Nu star	20.62
AppChi2	11.31
95% Gamma Approximate UCL	22.21
95% Adjusted Gamma UCL	22.99

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	12.46
SD	12.69
SE of Mean	2.327
95% KM (t) UCL	16.41
95% KM (z) UCL	16.29
95% KM (jackknife) UCL	16.4
95% KM (bootstrap t) UCL	18.72
95% KM (BCA) UCL	16.96
95% KM (Percentile Bootstrap) UCL	16.42
95% KM (Chebyshev) UCL	22.61
97.5% KM (Chebyshev) UCL	27
99% KM (Chebyshev) UCL	35.62

Potential UCLs to Use

95% KM (BCA) UCL	16.96

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Appendix C-6
ProUCL Output - Surface Water
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	SW.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Bromodichloromethane

General Statistics

Number of Valid Data	6	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	3
		Percent Non-Detects	50.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.38	Minimum Detected	-0.968
Maximum Detected	1	Maximum Detected	0
Mean of Detected	0.7	Mean of Detected	-0.432
SD of Detected	0.31	SD of Detected	0.492
Minimum Non-Detect	0.5	Minimum Non-Detect	-0.693
Maximum Non-Detect	0.5	Maximum Non-Detect	-0.693

Warning: There are only 3 Distinct Detected Values in this data set
The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.997	Shapiro Wilk Test Statistic	0.967
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.475	Mean	-0.909
SD	0.315	SD	0.608
95% DL/2 (t) UCL	0.734	95% H-Stat (DL/2) UCL	1.071
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-0.715
		SD in Log Scale	0.474
		Mean in Original Scale	0.539
		SD in Original Scale	0.272
		95% t UCL	0.763
		95% Percentile Bootstrap UCL	0.716
		95% BCA Bootstrap UCL	0.747
		95% H-UCL	0.944

Appendix C-6
ProUCL Output - Surface Water
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	
Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only	
Data appear Normal at 5% Significance Level	

Nonparametric Statistics	
Kaplan-Meier (KM) Method	
Mean	0.54
SD	0.24
SE of Mean	0.12
95% KM (t) UCL	0.782
95% KM (z) UCL	0.738
95% KM (jackknife) UCL	0.827
95% KM (bootstrap t) UCL	0.617
95% KM (BCA) UCL	1
95% KM (Percentile Bootstrap) UCL	1
95% KM (Chebyshev) UCL	1.064
97.5% KM (Chebyshev) UCL	1.29
99% KM (Chebyshev) UCL	1.735
Potential UCLs to Use	
95% KM (t) UCL	0.782
95% KM (Percentile Bootstrap) UCL	1

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Dibromochloromethane

General Statistics

Number of Valid Data	6	Number of Detected Data	3
Number of Distinct Detected Data	3	Number of Non-Detect Data	3
		Percent Non-Detects	50.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.57	Minimum Detected	-0.562
Maximum Detected	1.3	Maximum Detected	0.262
Mean of Detected	0.937	Mean of Detected	-0.121
SD of Detected	0.365	SD of Detected	0.415
Minimum Non-Detect	0.5	Minimum Non-Detect	-0.693
Maximum Non-Detect	0.5	Maximum Non-Detect	-0.693

Warning: There are only 3 Distinct Detected Values in this data set

The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.

Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.

However, results obtained using 4 to 9 distinct values may not be reliable.

It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	1	Shapiro Wilk Test Statistic	0.985
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.593	Mean	-0.753
SD	0.441	SD	0.741
95% DL/2 (t) UCL	0.956	95% H-Stat (DL/2) UCL	1.848
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.511	Mean in Log Scale	-0.817
SD	0.524	SD in Log Scale	0.847
95% MLE (t) UCL	0.942	Mean in Original Scale	0.585
95% MLE (Tiku) UCL	1.042	SD in Original Scale	0.453
		95% t UCL	0.957
		95% Percentile Bootstrap UCL	0.866
		95% BCA Bootstrap UCL	0.896
		95% H UCL	2.485

Appendix C-6
ProUCL Output - Surface Water
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test with Detected Values Only	
k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data appear Normal at 5% Significance Level

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.753
SD	0.279
SE of Mean	0.14
95% KM (t) UCL	1.035
95% KM (z) UCL	0.983
95% KM (jackknife) UCL	1.076
95% KM (bootstrap t) UCL	0.859
95% KM (BCA) UCL	1.3
95% KM (Percentile Bootstrap) UCL	1.3
95% KM (Chebyshev) UCL	1.362
97.5% KM (Chebyshev) UCL	1.626
99% KM (Chebyshev) UCL	2.143

Potential UCLs to Use

95% KM (t) UCL	1.035
95% KM (Percentile Bootstrap) UCL	1.3

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Appendix C-7
ProUCL Output - Sediment
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	SD.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic

General Statistics

Number of Valid Data	6	Number of Detected Data	2
Number of Distinct Detected Data	2	Number of Non-Detect Data	4
		Percent Non-Detects	66.67%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.65	Minimum Detected	-0.431
Maximum Detected	2.7	Maximum Detected	0.993
Mean of Detected	1.675	Mean of Detected	0.281
SD of Detected	1.45	SD of Detected	1.007
Minimum Non-Detect	0.5	Minimum Non-Detect	-0.693
Maximum Non-Detect	0.62	Maximum Non-Detect	-0.478

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	4
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	2
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	66.67%

Warning: Data set has only 2 Distinct Detected Values.
This may not be adequate enough to compute meaningful and reliable test statistics and estimates.
The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).

Unless Data Quality Objectives (DQOs) have been met, it is suggested to collect additional observations.

The number of detected data may not be adequate enough to perform GOF tests, bootstrap, and ROS methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values for bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10 to 15 or more observations for accurate and meaningful results and estimates.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	N/A	Shapiro Wilk Test Statistic	N/A
5% Shapiro Wilk Critical Value	N/A	5% Shapiro Wilk Critical Value	N/A
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.746	Mean	-0.754
SD	0.969	SD	0.922
95% DL/2 (t) UCL	1.543	95% H-Stat (DL/2) UCL	3.511

Maximum Likelihood Estimate(MLE) Method	N/A
MLE method failed to converge properly	

Log ROS Method	
Mean in Log Scale	N/A
SD in Log Scale	N/A
Mean in Original Scale	N/A
SD in Original Scale	N/A
95% t UCL	N/A
95% Percentile Bootstrap UCL	N/A
95% BCA Bootstrap UCL	N/A
95% H-UCL	N/A

Gamma Distribution Test with Detected Values Only

k star (bias corrected)	N/A
Theta Star	N/A
nu star	N/A
A-D Test Statistic	N/A
5% A-D Critical Value	N/A
K-S Test Statistic	N/A
5% K-S Critical Value	N/A

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

Gamma ROS Statistics using Extrapolated Data	
Minimum	N/A
Maximum	N/A
Mean	N/A
Median	N/A
SD	N/A
k star	N/A
Theta star	N/A
Nu star	N/A
AppChi2	N/A
95% Gamma Approximate UCL	N/A
95% Adjusted Gamma UCL	N/A

Note: DL/2 is not a recommended method.

Data Distribution Test with Detected Values Only

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

Kaplan-Meier (KM) Method	
Mean	0.992
SD	0.764
SE of Mean	0.441
95% KM (t) UCL	1.88
95% KM (z) UCL	1.717
95% KM (jackknife) UCL	2.594
95% KM (bootstrap t) UCL	N/A
95% KM (BCA) UCL	N/A
95% KM (Percentile Bootstrap) UCL	2.7
95% KM (Chebyshev) UCL	2.914
97.5% KM (Chebyshev) UCL	3.746
99% KM (Chebyshev) UCL	5.38

Potential UCLs to Use

95% KM (BCA) UCL	N/A

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Chromium

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	2.1	Minimum of Log Data	0.742
Maximum	6	Maximum of Log Data	1.792
Mean	3.6	Mean of log Data	1.229
Median	3.25	SD of log Data	0.348
SD	1.328		
Std. Error of Mean	0.542		
Coefficient of Variation	0.369		
Skewness	1.301		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.898	Shapiro Wilk Test Statistic	0.964
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	4.693	95% H-UCL	5.203
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	5.817
95% Adjusted-CLT UCL (Chen-1995)	4.8	97.5% Chebyshev (MVUE) UCL	6.779
95% Modified-t UCL (Johnson-1978)	4.741	99% Chebyshev (MVUE) UCL	8.67

Gamma Distribution Test

k star (bias corrected)	5.003
Theta Star	0.72
MLE of Mean	3.6
MLE of Standard Deviation	1.609
nu star	60.04
Approximate Chi Square Value (.05)	43.22
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	38.13
Anderson-Darling Test Statistic	0.293
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.194
Kolmogorov-Smirnov 5% Critical Value	0.332

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	5.001
95% Adjusted Gamma UCL	5.669

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	4.492
95% Jackknife UCL	4.693
95% Standard Bootstrap UCL	4.415
95% Bootstrap-t UCL	5.555
95% Hall's Bootstrap UCL	9.904
95% Percentile Bootstrap UCL	4.467
95% BCA Bootstrap UCL	4.65
95% Chebyshev(Mean, Sd) UCL	5.963
97.5% Chebyshev(Mean, Sd) UCL	6.986
99% Chebyshev(Mean, Sd) UCL	8.995

Potential UCL to Use

Use 95% Student's-t UCL 4.693

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Cobalt

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	2.5	Minimum of Log Data	0.916
Maximum	7.1	Maximum of Log Data	1.96
Mean	3.933	Mean of log Data	1.31
Median	3.55	SD of log Data	0.361
SD	1.643		
Std. Error of Mean	0.671		
Coefficient of Variation	0.418		
Skewness	1.864		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.804	Shapiro Wilk Test Statistic	0.908
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	5.285	95% H-UCL	5.767
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	6.421
95% Adjusted-CLT UCL (Chen-1995)	5.582	97.5% Chebyshev (MVUE) UCL	7.507
95% Modified-t UCL (Johnson-1978)	5.37	99% Chebyshev (MVUE) UCL	9.641

Appendix C-7
ProUCL Output - Sediment
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test

k star (bias corrected)	4.389
Theta Star	0.896
MLE of Mean	3.933
MLE of Standard Deviation	1.877
nu star	52.67
Approximate Chi Square Value (.05)	37
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	32.32
Anderson-Darling Test Statistic	0.445
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.268
Kolmogorov-Smirnov 5% Critical Value	0.333

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	5.599
95% Adjusted Gamma UCL	6.41

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	5.036
95% Jackknife UCL	5.285
95% Standard Bootstrap UCL	4.915
95% Bootstrap-t UCL	6.678
95% Hall's Bootstrap UCL	10.14
95% Percentile Bootstrap UCL	5.067
95% BCA Bootstrap UCL	5.35
95% Chebyshev(Mean, Sd) UCL	6.857
97.5% Chebyshev(Mean, Sd) UCL	8.122
99% Chebyshev(Mean, Sd) UCL	10.61

Potential UCL to Use

Use 95% Student's-t UCL 5.285

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Iron

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	5220	Minimum of Log Data	8.56
Maximum	13500	Maximum of Log Data	9.51
Mean	8155	Mean of log Data	8.961
Median	7435	SD of log Data	0.32
SD	2871		
Std. Error of Mean	1172		
Coefficient of Variation	0.352		
Skewness	1.556		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.868	Shapiro Wilk Test Statistic	0.95
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	10517	95% H-UCL	11338
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	12762
95% Adjusted-CLT UCL (Chen-1995)	10878	97.5% Chebyshev (MVUE) UCL	14765
95% Modified-t UCL (Johnson-1978)	10641	99% Chebyshev (MVUE) UCL	18699

Gamma Distribution Test

k star (bias corrected)	5.723
Theta Star	1425
MLE of Mean	8155
MLE of Standard Deviation	3409
nu star	68.67
Approximate Chi Square Value (.05)	50.6
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	45.04
Anderson-Darling Test Statistic	0.331
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.209
Kolmogorov-Smirnov 5% Critical Value	0.332

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	11068
95% Adjusted Gamma UCL	12433

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	10083
95% Jackknife UCL	10517
95% Standard Bootstrap UCL	9881
95% Bootstrap-t UCL	12751
95% Hall's Bootstrap UCL	20905
95% Percentile Bootstrap UCL	10098
95% BCA Bootstrap UCL	10358
95% Chebyshev(Mean, Sd) UCL	13264
97.5% Chebyshev(Mean, Sd) UCL	15475
99% Chebyshev(Mean, Sd) UCL	19817

Potential UCL to Use

Use 95% Student's-t UCL 10517

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Manganese

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	237	Minimum of Log Data	5.468
Maximum	333	Maximum of Log Data	5.808
Mean	284.3	Mean of log Data	5.645
Median	284.5	SD of log Data	0.112
SD	31.68		
Std. Error of Mean	12.93		
Coefficient of Variation	0.111		
Skewness	0.0814		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.967	Shapiro Wilk Test Statistic	0.965
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	310.4	95% H-UCL	314
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	341.2
95% Adjusted-CLT UCL (Chen-1995)	306.1	97.5% Chebyshev (MVUE) UCL	365.8
95% Modified-t UCL (Johnson-1978)	310.5	99% Chebyshev (MVUE) UCL	414.1

Gamma Distribution Test

k star (bias corrected)	48.07
Theta Star	5.915
MLE of Mean	284.3
MLE of Standard Deviation	41.01
nu star	576.9
Approximate Chi Square Value (.05)	522.2
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	503.2
Anderson-Darling Test Statistic	0.253
Anderson-Darling 5% Critical Value	0.696
Kolmogorov-Smirnov Test Statistic	0.179
Kolmogorov-Smirnov 5% Critical Value	0.332

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	314.1
95% Adjusted Gamma UCL	326

Data Distribution

Data appear Normal at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	305.6
95% Jackknife UCL	310.4
95% Standard Bootstrap UCL	303.8
95% Bootstrap-t UCL	310.3
95% Hall's Bootstrap UCL	313.9
95% Percentile Bootstrap UCL	304.2
95% BCA Bootstrap UCL	303.5
95% Chebyshev(Mean, Sd) UCL	340.7
97.5% Chebyshev(Mean, Sd) UCL	365.1
99% Chebyshev(Mean, Sd) UCL	413

Potential UCL to Use

Use 95% Student's-t UCL 310.4

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Vanadium

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		Log-transformed Statistics	
Minimum	33.5	Minimum of Log Data	3.512
Maximum	70.6	Maximum of Log Data	4.257
Mean	41.27	Mean of log Data	3.681
Median	35.55	SD of log Data	0.285
SD	14.44		
Std. Error of Mean	5.895		
Coefficient of Variation	0.35		
Skewness	2.398		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.589	Shapiro Wilk Test Statistic	0.628
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	

Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	53.14	95% H-UCL	54.71
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	61.86
95% Adjusted-CLT UCL (Chen-1995)	57.13	97.5% Chebyshev (MVUE) UCL	70.86
95% Modified-t UCL (Johnson-1978)	54.11	99% Chebyshev (MVUE) UCL	88.54

Appendix C-7
ProUCL Output - Sediment
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Gamma Distribution Test	
k star (bias corrected)	6.614
Theta Star	6.24
MLE of Mean	41.27
MLE of Standard Deviation	16.05
nu star	79.36
Approximate Chi Square Value (.05)	59.84
Adjusted Level of Significance	0.0122
Adjusted Chi Square Value	53.76
Anderson-Darling Test Statistic	1.254
Anderson-Darling 5% Critical Value	0.698
Kolmogorov-Smirnov Test Statistic	0.423
Kolmogorov-Smirnov 5% Critical Value	0.332

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution	
95% Approximate Gamma UCL	54.73
95% Adjusted Gamma UCL	60.93

Potential UCL to Use

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics	
95% CLT UCL	50.96
95% Jackknife UCL	53.14
95% Standard Bootstrap UCL	50.28
95% Bootstrap-t UCL	137.4
95% Hall's Bootstrap UCL	115.4
95% Percentile Bootstrap UCL	52.67
95% BCA Bootstrap UCL	53.87
95% Chebyshev(Mean, Sd) UCL	66.96
97.5% Chebyshev(Mean, Sd) UCL	78.08
99% Chebyshev(Mean, Sd) UCL	99.92

Use 95% Student's-t UCL 53.14
or 95% Modified-t UCL 54.11

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Appendix D

Shower Model

Input Assumptions and Estimated Air Concentrations

Appendix D Contents
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

TABLE D-1
VALUES USED FOR SHOWER MODEL
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater or Surface Water
Exposure Medium:	Air
Receptor Population:	Resident or Commercial/Industrial Worker
Receptor Age:	Adult

Exposure Route	Parameter Code	Parameter Definition	Unit	Reasonable Maximum Exposure		Central Tendency Exposure		Intake Equation/ Model Name
				Value	Reference	Value	Reference	
Inhalation	CW	Chemical Concentration in Water	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Maximum air concentration in bathroom
	f	Fraction volatilized	--	chem-specific	Schaum et al. (1)	chem-specific	Schaum et al. (1)	(C_{aMax}) (µg/m^3) =
	F_w	Flow Rate	L/hr	1000	Schaum et al.	500	Schaum et al.	CW x f x Fw x t_1 x 1/Va
	t_1	Time of shower	hr	0.25	EPA 2004	0.10	EPA 2004	
	V_a	Bathroom volume	m^3	6	Schaum et al.	16	Schaum et al.	EPC (µg/m^3) =
	t_2	Time after shower in bathroom	hr	0.33	EPA 2004	0.15	EPA 2004	(((C_{aMax}2) x t_1) + (C_{aMax} x t_2)) / (t_1 + t_2)

EPC = Exposure Point Concentration, the average air concentration in the bathroom during and after shower
µg = microgram
L = liter
hr = hour
m = meter
Note:
(1) applies only to volatile chemicals
Sources:
EPA 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005.
Schaum *et al*. 1994. *Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water*. Water Contamination and Health, edited by Rhoda G.M. Wang. New York: Marcel Dekker, Inc.

TABLE D-2
VALUES USED FOR SHOWER MODEL
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater or Surface Water
Exposure Medium:	Air
Receptor Population:	Resident
Receptor Age:	Child (0-6 years)

Exposure Route	Parameter Code	Parameter Definition	Unit	Reasonable Maximum Exposure		Central Tendency Exposure		Intake Equation/ Model Name
				Value	Reference	Value	Reference	
Inhalation	CW	Chemical Concentration in Water	µg/L	Table B-3.3	Table B-3.3	Table B-3.3	Table B-3.3	Maximum air concentration in bathroom
	f	Fraction volatilized	--	chem-specific	Schaum et al. (1)	chem-specific	Schaum et al. (1)	(C_{aMax}) (µg/m^3) =
	F_w	Flow Rate	L/hr	1000	Schaum et al.	500	Schaum et al.	CW x f x Fw x t_1 x 1/Va
	t_1	Time of shower	hr	0.45	EPA 2004	0.14	EPA 2004	
	V_a	Bathroom volume	m^3	6	Schaum et al.	16	Schaum et al.	EPC (µg/m^3) =
	t_2	Time after shower in bathroom	hr	0.55	EPA 2004	0.19	EPA 2004	(((C_{aMax}2) x t_1) + (C_{aMax} x t_2)) / (t_1 + t_2)

EPC = Exposure Point Concentration, the average air concentration in the bathroom during and after shower
µg = microgram
L = liter
hr = hour
m = meter
Note:
(1) applies only to volatile chemicals
Sources:
EPA 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005.
Schaum *et al*. 1994. *Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water*. Water Contamination and Health, edited by Rhoda G.M. Wang. New York: Marcel Dekker, Inc.

TABLE D-3

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Air
Receptor Population:	Resident or Commercial/Industrial Worker
Receptor Age:	Adult

Exposure Point	CAS No.	Chemical of Potential Concern	Groundwater Exposure Point Concentration (EPC) (µg/L)	Fraction Volatilized	Reasonable Maximum Exposure		Central Tendency Exposure	
					C_{aMax} (µg/m^3)	Air EPC (µg/m^3)	C_{aMax} (µg/m^3)	Air EPC (µg/m^3)
Water Vapor at Showerhead		**Volatile Organic Compounds**						
	156-59-2	cis-1,2-Dichloroethene	5.4E+01	5.6E-01	1.3E+03	1.0E+03	9.6E+01	7.7E+01
	127-18-4	Tetrachloroethene	9.9E-01	5.0E-01	2.1E+01	1.6E+01	1.5E+00	1.2E+00
	156-60-5	trans-1,2-Dichloroethene	2.3E+00	5.6E-01	5.3E+01	4.2E+01	4.0E+00	3.2E+00
	79-01-6	Trichloroethene	5.6E-01	5.3E-01	1.2E+01	9.7E+00	9.3E-01	7.4E-01
	75-01-4	Vinyl Chloride	7.3E-01	5.9E-01	1.8E+01	1.4E+01	1.3E+00	1.1E+00

EPC = Exposure Point Concentration, the average air concentration in the bathroom during and after shower

µg/L = microgram per liter

µg/m^3 = microgram per cubic meter

TABLE D-4

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Air
Receptor Population:	Resident
Receptor Age:	Child (0-6 years)

Exposure Point	CAS No.	Chemical of Potential Concern	Groundwater Exposure Point Concentration (EPC) (µg/L)	Fraction Volatilized	Reasonable Maximum Exposure		Central Tendency Exposure	
					C_{aMax} (µg/m^3)	Air EPC (µg/m^3)	C_{aMax} (µg/m^3)	Air EPC (µg/m^3)
Water Vapor at Showerhead		**Volatile Organic Compounds**						
	156-59-2	cis-1,2-Dichloroethene	5.4E+01	5.6E-01	2.3E+03	1.8E+03	1.3E+02	1.1E+02
	127-18-4	Tetrachloroethene	9.9E-01	5.0E-01	3.7E+01	2.9E+01	2.2E+00	1.7E+00
	156-60-5	trans-1,2-Dichloroethene	2.3E+00	5.6E-01	9.6E+01	7.4E+01	5.6E+00	4.4E+00
	79-01-6	Trichloroethene	5.6E-01	5.3E-01	2.2E+01	1.7E+01	1.3E+00	1.0E+00
	75-01-4	Vinyl Chloride	7.3E-01	5.9E-01	3.2E+01	2.5E+01	1.9E+00	1.5E+00

EPC = Exposure Point Concentration, the average air concentration in the bathroom during and after shower

µg/L = microgram per liter

µg/m^3 = microgram per cubic meter

TABLE D-5

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Future
Medium:	Surface Water
Exposure Medium:	Air
Receptor Population:	Resident
Receptor Age:	Adult

Exposure Point	CAS No.	Chemical of Potential Concern	Groundwater Exposure Point Concentration (EPC) (µg/L)	Fraction Volatilized	Reasonable Maximum Exposure		Central Tendency Exposure	
					C_{aMax} (µg/m^3)	Air EPC (µg/m^3)	C_{aMax} (µg/m^3)	Air EPC (µg/m^3)
Water Vapor at Showerhead		**Volatile Organic Compounds**						
	75-27-4	Bromodichloromethane	1.0E+00	5.4E-01	2.3E+01	1.8E+01	1.7E+00	1.4E+00
	124-48-1	Dibromochloromethane	1.3E+00	5.4E-01	2.9E+01	2.3E+01	2.2E+00	1.8E+00

EPC = Exposure Point Concentration, the average air concentration in the bathroom during and after shower

µg/L = microgram per liter

µg/m^3 = microgram per cubic meter

TABLE D-6

MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Scenario Timeframe:	Future
Medium:	Surface Water
Exposure Medium:	Air
Receptor Population:	Resident
Receptor Age:	Child (0-6 years)

Exposure Point	CAS No.	Chemical of Potential Concern	Groundwater Exposure Point Concentration (EPC) (µg/L)	Fraction Volatilized	Reasonable Maximum Exposure		Central Tendency Exposure	
					C_{aMax} (µg/m^3)	Air EPC (µg/m^3)	C_{aMax} (µg/m^3)	Air EPC (µg/m^3)
Water Vapor at Showerhead		**Volatile Organic Compounds**						
	75-27-4	Bromodichloromethane	1.0E+00	5.4E-01	4.1E+01	3.2E+01	2.4E+00	1.9E+00
	124-48-1	Dibromochloromethane	1.3E+00	5.4E-01	5.3E+01	4.1E+01	3.1E+00	2.4E+00

EPC = Exposure Point Concentration, the average air concentration in the bathroom during and after shower

µg/L = microgram per liter

µg/m^3 = microgram per cubic meter

Appendix E

Vapor Intrusion Screening

Appendix E Contents
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Vapor Evaluation of Site Groundwater
Table E-1 Comparison of Maximum Detected Concentrations to Vapor Intrusion Screening Levels

Appendix E
Vapor Evaluation of Site Groundwater

CDM Smith performed a screening evaluation of the vapor intrusion pathway at the Maunabo Groundwater Contamination Site (Table E-1). The following contaminants were identified as contaminants of potential concern (COPCs) for the vapor intrusion pathway when the maximum detected concentrations in groundwater were compared to their respective screening levels (Table 2c of EPA 2002): bromoform, cis-1,2-dichloroethene (cis-1,2-DCE), tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride.

CDM Smith has evaluated the distribution of these COPCs in groundwater based on the groundwater screening survey and monitoring well data from the Maunabo Remedial Investigation (RI) report (Figures 4-6 and 4-7, respectively, in the RI report), to determine if vapor intrusion is potentially a complete exposure pathway. The RI report identified three distinct plumes at the site (Figure 4-9 in the RI report). Each plume area was evaluated for the potential for vapor intrusion, as summarized below.

Groundwater Plume North of Maunabo #1 Supply Well

- The groundwater plume is in an area that is largely rural, with no buildings or structures. The only building in the area is the Puerto Rico Beverage (PRB) building.
- The concentration of at least one of the five COPCs for the vapor intrusion pathway exceeded the screening levels at MW-AD, MW-B, and MW-I. MW-AD and MW-I are located more than 100 feet from the PRB building. MW-B is located within 100 feet of the PRB building; however, the COPCs were not detected above the screening levels at T1-C, which is the groundwater screening survey for MW-B, (Figure 4-6 in the RI report) at the top of the groundwater table (6 to 10 feet below ground surface). Other screening locations (T1-N, GS-B, and T1-L) which are closer to the PRB building and located between T1-C/MW-B and the PRB building also had no detections of COPCs above screening levels at the top of the groundwater table.

Groundwater Plume South of Maunabo #1 Supply Well

- The groundwater plume south of the Rio Maunabo and the Maunabo #1 supply well is underneath several residences.
- The concentration of at least one of the five COPCs (PCE and TCE) for the vapor intrusion pathway exceeded the screening levels at MW-C, MW-FS, and MW-FD. MW-C is located more than 100 feet from the nearby residence. MW-FS and MW-FD are located within 100 feet of the nearby residence. The groundwater screening survey results at T4-C, which is the groundwater screening survey for MW-FS/FD, indicated that there is an uncontaminated layer of groundwater above the contaminated groundwater.

Groundwater Plume North of Maunabo #4 Supply Well

- This groundwater plume is in an area that is largely rural, with few buildings or structures.
- The concentration of one of the COPCs (bromoform) for the vapor intrusion pathway exceeded the screening levels at MW-M and MW-N. Both wells are located more than 100 feet from nearby buildings.

Conclusions and Recommendations

- The three groundwater plumes identified at the site are primarily in undeveloped areas with minimal structures.
- The concentration of the five COPCs for the vapor intrusion pathways exceeded the screening levels at three locations near buildings or structures in the area north and south of the Maunabo #1.
- COPCs were not detected in the top 15 to 20 feet of groundwater in the majority of groundwater screening samples.
- Based on the available data, vapor intrusion sampling (i.e., subslab and indoor air) is not warranted at this time because the existing structures are not near the COPC concentrations which exceed the screening levels and no detections of COPCs were above the screening levels at the top of the water table. In addition, the majority of the site area has uncontaminated groundwater in the top 15 to 20 feet (and more in some locations) of the water table.

TABLE E-1

COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS TO VAPOR INTRUSION SCREENING LEVELS

Maunabo Groundwater Contamination Site

Maunabo, Puerto Rico

Exposure Point	CAS No.	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Unit	Location of Maximum Concentration	Detection Frequency	Range of Reporting Limit	Concentration Used for Screening [1]	Screening Toxicity Value (n/c) [2]	COPC Flag (Yes/No)
Groundwater	**Volatile Organic Compounds**										
	76-13-1	1,1,2-Trichloro-1,2,2-Trifluoroethane	3.2	23	µg/L	MW-AD	5 / 35	0.5 - 0.5	23	1500 n	No
	75-34-3	1,1-Dichloroethane	0.27 J	0.75	µg/L	MW-I	6 / 35	0.5 - 0.5	0.75	2200 n	No
	75-35-4	1,1-Dichloroethene	0.22 J	25 J	µg/L	MW-L	12 / 35	0.5 - 0.5	25	190 n	No
	107-06-2	1,2-Dichloroethane	0.2	0.2	µg/L	MW-AD	1 / 35	0.2 - 0.2	0.2	2.3 c	No
	78-87-5	1,2-Dichloropropane	0.52	0.52	µg/L	MW-N	1 / 35	0.2 - 0.2	0.52	35 n	No
	67-64-1	Acetone	1.6 J	15	µg/L	MW-N	2 / 35	5 - 5	15	220000 n	No
	75-25-2	**Bromoform**	**1.6**	**5**	**µg/L**	**MW-M**	**3 / 35**	**0.5 - 0.5**	**5**	**0.083 c**	**Yes**
	75-15-0	Carbon Disulfide	1.4	1.4	µg/L	MW-AS	1 / 35	0.5 - 0.5	1.4	560 n	No
	75-00-3	Chloroethane	0.27 J	0.27 J	µg/L	MW-I	1 / 35	0.5 - 0.5	0.27	28000 n	No
	156-59-2	**cis-1,2-Dichloroethene**	**0.38 J**	**300**	**µg/L**	**MW-B**	**16 / 35**	**0.5 - 0.5**	**300**	**210 n**	**Yes**
	124-48-1	Dibromochloromethane	0.54	0.54	µg/L	MW-M	1 / 35	0.5 - 0.5	0.54	3.2 c	No
	1634-04-4	Methyl Tert-Butyl Ether	0.27 J	2	µg/L	MW-K	8 / 35	0.5 - 0.5	2	120000 n	No
	75-09-2	Methylene Chloride	1.3	1.7	µg/L	MW-FD	4 / 35	0.5 - 0.5	1.7	58 c	No
	127-18-4	**Tetrachloroethene**	**0.1 J**	**8.5 J**	**µg/L**	**MW-FD**	**9 / 35**	**0.2 - 0.2**	**8.5**	**1.1 c**	**Yes**
	156-60-5	trans-1,2-Dichloroethene	0.99	13	µg/L	MW-B	4 / 35	0.5 - 0.5	13	180 n	No
	10061-02-6	trans-1,3-Dichloropropene	0.2 J	0.2 J	µg/L	MW-N	1 / 35	0.2 - 0.2	0.2	0.84 n[3]	No
	79-01-6	**Trichloroethene**	**0.29 J**	**1.9**	**µg/L**	**MW-FD**	**7 / 35**	**0.5 - 0.5**	**1.9**	**0.053 c**	**Yes**
	75-69-4	Trichlorofluoromethane	0.36 J	8	µg/L	MW-L	6 / 35	0.5 - 0.5	8	180 n	No
	75-01-4	**Vinyl Chloride**	**0.22**	**0.73**	**µg/L**	**MW-B**	**3 / 35**	**0.2 - 0.2**	**0.73**	**0.25 c**	**Yes**

[1] Maximum detected concentration used for screening

[2] Screened against Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater Table 2c: Generic Screening Levels and Summary Sheet, Risk =1×10^{-6} and for value based on MCL, refers to Table 2a (risk = 1 x 10^{-4}) and adjusted the value to a 10^{-6} value
http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf

[3] screening value for 1,3-dichloropropene

NA = not available
n = screening toxicity value based on noncancer effects
c = screening toxicity value based on cancer effects
COPC = chemical of potential concern
J = qualifier for estimated value
µg/L = micrograms per liter

Appendix F

RAGS D Tables – CTE Scenario

Appendix F Contents
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

TABLE F-7.1
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Former Sugar Mill	Ingestion	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	3.62E-09	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	2.64E-08	2.81E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	9.92E-10	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	7.24E-09	7.71E-09	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	7.59E-04	mg/kg-day	NA	NA	NA	5.90E-03	mg/kg-day	1.00E+00	mg/kg-day	5.90E-03
				Arsenic	3.64E+00	mg/kg	2.00E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	3.00E-07	1.56E-06	mg/kg-day	3.00E-04	mg/kg-day	5.19E-03
				Chromium	1.50E+01	mg/kg	8.28E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	4.14E-07	6.44E-06	mg/kg-day	3.00E-03	mg/kg-day	2.15E-03
				Cobalt	8.79E+00	mg/kg	4.84E-07	mg/kg-day	NA	NA	NA	3.77E-06	mg/kg-day	3.00E-04	mg/kg-day	1.26E-02
				Iron	3.74E+04	mg/kg	2.06E-03	mg/kg-day	NA	NA	NA	1.60E-02	mg/kg-day	7.00E-01	mg/kg-day	2.29E-02
				Manganese	4.89E+02	mg/kg	2.69E-05	mg/kg-day	NA	NA	NA	2.09E-04	mg/kg-day	1.40E-01	mg/kg-day	1.50E-03
				Vanadium	6.37E+01	mg/kg	3.51E-06	mg/kg-day	NA	NA	NA	2.73E-05	mg/kg-day	7.00E-05	mg/kg-day	3.90E-01
			Exp. Route Total								7.48E-07					4.40E-01
Surface Soil	Surface Soil	Former Sugar Mill	Dermal Contact	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	6.21E-10	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	4.53E-09	4.83E-09	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.70E-10	mg/kg-day	7.30E+00	$(mg/kg\text{-}day)^{-1}$	1.24E-09	1.32E-09	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	3.64E+00	mg/kg	7.93E-09	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.19E-08	6.17E-08	mg/kg-day	3.00E-04	mg/kg-day	2.06E-04
				Chromium	1.50E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	8.79E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	3.74E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	4.89E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	6.37E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								1.77E-08					2.06E-04
Surface Soil	Surface Soil	Former Sugar Mill	Inhalation	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	6.20E-10	$\mu g/m^3$	1.10E-03	$(\mu g/m^3)^{-1}$	6.82E-13	4.83E-12	mg/m^3	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.70E-10	$\mu g/m^3$	1.20E-03	$(\mu g/m^3)^{-1}$	2.04E-13	1.32E-12	mg/m^3	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	1.30E-04	$\mu g/m^3$	NA	NA	NA	1.01E-06	mg/m^3	5.00E-03	mg/m^3	2.03E-04
				Arsenic	3.64E+00	mg/kg	3.44E-08	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	1.48E-10	2.67E-10	mg/m^3	1.50E-05	mg/m^3	1.78E-05
				Chromium	1.50E+01	mg/kg	1.42E-07	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	1.71E-09	1.11E-09	mg/m^3	1.00E-04	mg/m^3	1.11E-05
				Cobalt	8.79E+00	mg/kg	8.31E-08	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	7.48E-10	6.46E-10	mg/m^3	6.00E-06	mg/m^3	1.08E-04
				Iron	3.74E+04	mg/kg	3.54E-04	$\mu g/m^3$	NA	NA	NA	2.75E-06	mg/m^3	NA	NA	NA
				Manganese	4.89E+02	mg/kg	4.62E-06	$\mu g/m^3$	NA	NA	NA	3.59E-08	mg/m^3	5.00E-05	mg/m^3	7.18E-04
				Vanadium	6.37E+01	mg/kg	6.02E-07	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	5.00E-09	4.68E-09	mg/m^3	1.00E-04	mg/m^3	4.68E-05
			Exp. Route Total								7.60E-09					1.10E-03
		Exposure Point Total									7.73E-07					4.42E-01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-7.1
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	6.00E-05	mg/kg-day	NA	NA	NA	4.67E-04	mg/kg-day	2.00E-03	mg/kg-day	2.33E-01
				Tetrachloroethene	9.92E-01	µg/L	1.09E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	2.30E-09	8.50E-06	mg/kg-day	6.00E-03	mg/kg-day	1.42E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	2.52E-06	mg/kg-day	NA	NA	NA	1.96E-05	mg/kg-day	2.00E-02	mg/kg-day	9.78E-04
				Trichloroethene	5.64E-01	µg/L	6.22E-07	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	2.86E-08	4.83E-06	mg/kg-day	5.00E-04	mg/kg-day	9.67E-03
				Vinyl Chloride	7.30E-01	µg/L	8.04E-07	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	5.79E-07	6.26E-06	mg/kg-day	3.00E-03	mg/kg-day	2.09E-03
				Inorganics												
				Aluminum	2.04E+03	µg/L	2.25E-03	mg/kg-day	NA	NA	NA	1.75E-02	mg/kg-day	1.00E+00	mg/kg-day	1.75E-02
				Arsenic	3.80E+00	µg/L	4.18E-06	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	6.27E-06	3.25E-05	mg/kg-day	3.00E-04	mg/kg-day	1.08E-01
				Barium	2.04E+02	µg/L	2.24E-04	mg/kg-day	NA	NA	NA	1.75E-03	mg/kg-day	2.00E-01	mg/kg-day	8.73E-03
				Chromium	8.35E+00	µg/L	9.20E-06	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	4.60E-06	7.16E-05	mg/kg-day	3.00E-03	mg/kg-day	2.39E-02
				Cobalt	1.07E+00	µg/L	1.18E-06	mg/kg-day	NA	NA	NA	9.21E-06	mg/kg-day	3.00E-04	mg/kg-day	3.07E-02
				Copper	5.22E+01	µg/L	5.76E-05	mg/kg-day	NA	NA	NA	4.48E-04	mg/kg-day	4.00E-02	mg/kg-day	1.12E-02
				Iron	8.20E+03	µg/L	9.03E-03	mg/kg-day	NA	NA	NA	7.03E-02	mg/kg-day	7.00E-01	mg/kg-day	1.00E-01
				Manganese	4.12E+02	µg/L	4.54E-04	mg/kg-day	NA	NA	NA	3.53E-03	mg/kg-day	1.40E-01	mg/kg-day	2.52E-02
				Vanadium	1.70E+01	µg/L	1.87E-05	mg/kg-day	NA	NA	NA	1.45E-04	mg/kg-day	7.00E-05	mg/kg-day	2.08E+00
			Exp. Route Total								1.15E-05					2.65E+00
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	8.56E-07	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	1.80E-09	6.66E-06	mg/kg-day	6.00E-03	mg/kg-day	1.11E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	2.93E-07	mg/kg-day	NA	NA	NA	2.28E-06	mg/kg-day	2.00E-02	mg/kg-day	1.14E-04
				Trichloroethene	5.64E-01	µg/L	1.41E-07	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	6.50E-09	1.10E-06	mg/kg-day	5.00E-04	mg/kg-day	2.20E-03
				Vinyl Chloride	7.30E-01	µg/L	5.49E-08	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	3.95E-08	4.27E-07	mg/kg-day	3.00E-03	mg/kg-day	1.42E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	1.01E-05	mg/kg-day	NA	NA	NA	7.86E-05	mg/kg-day	1.00E+00	mg/kg-day	7.86E-05
				Arsenic	3.80E+00	µg/L	1.88E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.82E-08	1.46E-07	mg/kg-day	3.00E-04	mg/kg-day	4.88E-04
				Barium	2.04E+02	µg/L	1.01E-06	mg/kg-day	NA	NA	NA	7.85E-06	mg/kg-day	1.40E-02	mg/kg-day	5.61E-04
				Chromium	8.35E+00	µg/L	4.14E-08	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	2.07E-08	3.22E-07	mg/kg-day	7.50E-05	mg/kg-day	4.29E-03
				Cobalt	1.07E+00	µg/L	2.13E-09	mg/kg-day	NA	NA	NA	1.66E-08	mg/kg-day	3.00E-04	mg/kg-day	5.52E-05
				Copper	5.22E+01	µg/L	2.59E-07	mg/kg-day	NA	NA	NA	2.01E-06	mg/kg-day	4.00E-02	mg/kg-day	5.04E-05
				Iron	8.20E+03	µg/L	4.06E-05	mg/kg-day	NA	NA	NA	3.16E-04	mg/kg-day	7.00E-01	mg/kg-day	4.52E-04
				Manganese	4.12E+02	µg/L	2.04E-06	mg/kg-day	NA	NA	NA	1.59E-05	mg/kg-day	5.60E-03	mg/kg-day	2.84E-03
				Vanadium	1.70E+01	µg/L	8.41E-08	mg/kg-day	NA	NA	NA	6.54E-07	mg/kg-day	1.82E-06	mg/kg-day	3.59E-01
			Exp. Route Total								9.68E-08					3.72E-01
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	1.00E+03	$\mu g/m^3$	8.05E-01	$\mu g/m^3$	NA	NA	NA	6.26E-03	mg/m^3	NA	NA	NA
				Tetrachloroethene	1.62E+01	$\mu g/m^3$	1.30E-02	$\mu g/m^3$	2.60E-07	$(\mu g/m^3)^{-1}$	3.39E-09	1.01E-04	mg/m^3	4.00E-02	mg/m^3	2.53E-03
				trans-1,2-Dichloroethene	4.18E+01	$\mu g/m^3$	3.36E-02	$\mu g/m^3$	NA	NA	NA	2.61E-04	mg/m^3	6.00E-02	mg/m^3	4.35E-03
				Trichloroethene	9.69E+00	$\mu g/m^3$	7.79E-03	$\mu g/m^3$	4.10E-06	$(\mu g/m^3)^{-1}$	3.19E-08	6.06E-05	mg/m^3	2.00E-03	mg/m^3	3.03E-02
				Vinyl Chloride	1.40E+01	$\mu g/m^3$	1.12E-02	$\mu g/m^3$	4.40E-06	$(\mu g/m^3)^{-1}$	4.95E-08	8.74E-05	mg/m^3	1.00E-01	mg/m^3	8.74E-04
			Exp. Route Total								8.48E-08					3.80E-02
		Exposure Point Total									1.17E-05					3.06E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-7.2
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Former Sugar Mill	Ingestion	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	2.09E-07	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	1.53E-06	4.20E-07	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	5.74E-08	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	4.19E-07	1.15E-07	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	8.76E-03	mg/kg-day	NA	NA	NA	8.81E-02	mg/kg-day	1.00E+00	mg/kg-day	8.81E-02
				Arsenic	3.64E+00	mg/kg	2.31E-06	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	3.47E-06	2.32E-05	mg/kg-day	3.00E-04	mg/kg-day	7.75E-02
				Chromium	1.50E+01	mg/kg	9.56E-06	mg/kg-day	5.00E-01	$(mg/kg-day)^{-1}$	4.78E-06	9.61E-05	mg/kg-day	3.00E-03	mg/kg-day	3.20E-02
				Cobalt	8.79E+00	mg/kg	5.59E-06	mg/kg-day	NA	NA	NA	5.62E-05	mg/kg-day	3.00E-04	mg/kg-day	1.87E-01
				Iron	3.74E+04	mg/kg	2.38E-02	mg/kg-day	NA	NA	NA	2.39E-01	mg/kg-day	7.00E-01	mg/kg-day	3.42E-01
				Manganese	4.89E+02	mg/kg	3.11E-04	mg/kg-day	NA	NA	NA	3.12E-03	mg/kg-day	1.40E-01	mg/kg-day	2.23E-02
				Vanadium	6.37E+01	mg/kg	4.05E-05	mg/kg-day	NA	NA	NA	4.07E-04	mg/kg-day	7.00E-05	mg/kg-day	5.82E+00
			Exp. Route Total								1.02E-05					6.57E+00
Surface Soil	Surface Soil	Former Sugar Mill	Dermal Contact	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	3.05E-08	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	2.23E-07	6.11E-08	mg/kg-day	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	8.36E-09	mg/kg-day	7.30E+00	$(mg/kg-day)^{-1}$	6.11E-08	1.68E-08	mg/kg-day	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	3.64E+00	mg/kg	7.79E-08	mg/kg-day	1.50E+00	$(mg/kg-day)^{-1}$	1.17E-07	7.81E-07	mg/kg-day	3.00E-04	mg/kg-day	2.60E-03
				Chromium	1.50E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg-day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	8.79E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	3.74E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	4.89E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	6.37E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								4.00E-07					2.60E-03
Surface Soil	Surface Soil	Former Sugar Mill	Inhalation	**Semi-volatile Organic Compounds**												
				Benzo(a)pyrene	6.56E-02	mg/kg	5.02E-08	$\mu g/m^3$	1.10E-03	$(\mu g/m^3)^{-1}$	5.53E-11	4.63E-11	mg/m^3	NA	NA	NA
				Dibenzo(a,h)anthracene	1.80E-02	mg/kg	1.38E-08	$\mu g/m^3$	1.20E-03	$(\mu g/m^3)^{-1}$	1.65E-11	1.27E-11	mg/m^3	NA	NA	NA
				Inorganics												
				Aluminum	1.38E+04	mg/kg	2.08E-03	$\mu g/m^3$	NA	NA	NA	9.71E-06	mg/m^3	5.00E-03	mg/m^3	1.94E-03
				Arsenic	3.64E+00	mg/kg	5.49E-07	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	2.36E-09	2.56E-09	mg/m^3	1.50E-05	mg/m^3	1.71E-04
				Chromium	1.50E+01	mg/kg	2.27E-06	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	2.73E-08	1.06E-08	mg/m^3	1.00E-04	mg/m^3	1.06E-04
				Cobalt	8.79E+00	mg/kg	1.33E-06	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	1.19E-08	6.20E-09	mg/m^3	6.00E-06	mg/m^3	1.03E-03
				Iron	3.74E+04	mg/kg	5.66E-03	$\mu g/m^3$	NA	NA	NA	2.64E-05	mg/m^3	NA	NA	NA
				Manganese	4.89E+02	mg/kg	7.38E-05	$\mu g/m^3$	NA	NA	NA	3.44E-07	mg/m^3	5.00E-05	mg/m^3	6.89E-03
				Vanadium	6.37E+01	mg/kg	9.63E-06	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	7.99E-08	4.49E-08	mg/m^3	1.00E-04	mg/m^3	4.49E-04
			Exp. Route Total								1.22E-07					1.06E-02
		Exposure Point Total									1.07E-05					6.58E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-7.2
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	2.54E-04	mg/kg-day	NA	NA	NA	1.39E-03	mg/kg-day	2.00E-03	mg/kg-day	6.96E-01
				Tetrachloroethene	9.92E-01	µg/L	4.62E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	9.70E-09	2.54E-05	mg/kg-day	6.00E-03	mg/kg-day	4.23E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.06E-05	mg/kg-day	NA	NA	NA	5.84E-05	mg/kg-day	2.00E-02	mg/kg-day	2.92E-03
				Trichloroethene	5.64E-01	µg/L	1.08E-05	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	1.97E-07	1.44E-05	mg/kg-day	5.00E-04	mg/kg-day	2.88E-02
				Vinyl Chloride	7.30E-01	µg/L	2.29E-05	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.65E-05	1.87E-05	mg/kg-day	3.00E-03	mg/kg-day	6.22E-03
				Inorganics												
				Aluminum	2.04E+03	µg/L	9.49E-03	mg/kg-day	NA	NA	NA	5.21E-02	mg/kg-day	1.00E+00	mg/kg-day	5.21E-02
				Arsenic	3.80E+00	µg/L	1.77E-05	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.65E-05	9.70E-05	mg/kg-day	3.00E-04	mg/kg-day	3.23E-01
				Barium	2.04E+02	µg/L	9.48E-04	mg/kg-day	NA	NA	NA	5.21E-03	mg/kg-day	2.00E-01	mg/kg-day	2.60E-02
				Chromium	8.35E+00	µg/L	3.89E-05	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	1.94E-05	2.13E-04	mg/kg-day	3.00E-03	mg/kg-day	7.12E-02
				Cobalt	1.07E+00	µg/L	5.00E-06	mg/kg-day	NA	NA	NA	2.75E-05	mg/kg-day	3.00E-04	mg/kg-day	9.15E-02
				Copper	5.22E+01	µg/L	2.43E-04	mg/kg-day	NA	NA	NA	1.34E-03	mg/kg-day	4.00E-02	mg/kg-day	3.34E-02
				Iron	8.20E+03	µg/L	3.82E-02	mg/kg-day	NA	NA	NA	2.10E-01	mg/kg-day	7.00E-01	mg/kg-day	2.99E-01
				Manganese	4.12E+02	µg/L	1.92E-03	mg/kg-day	NA	NA	NA	1.05E-02	mg/kg-day	1.40E-01	mg/kg-day	7.53E-02
				Vanadium	1.70E+01	µg/L	7.90E-05	mg/kg-day	NA	NA	NA	4.34E-04	mg/kg-day	7.00E-05	mg/kg-day	6.20E+00
			Exp. Route Total								6.26E-05					7.91E+00
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	3.11E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	6.53E-09	1.93E-05	mg/kg-day	6.00E-03	mg/kg-day	3.22E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.07E-06	mg/kg-day	NA	NA	NA	6.62E-06	mg/kg-day	2.00E-02	mg/kg-day	3.31E-04
				Trichloroethene	5.64E-01	µg/L	2.18E-06	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	3.93E-08	3.19E-06	mg/kg-day	5.00E-04	mg/kg-day	6.38E-03
				Vinyl Chloride	7.30E-01	µg/L	6.98E-15	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	5.03E-15	1.24E-06	mg/kg-day	3.00E-03	mg/kg-day	4.13E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	3.90E-05	mg/kg-day	NA	NA	NA	2.42E-04	mg/kg-day	1.00E+00	mg/kg-day	2.42E-04
				Arsenic	3.80E+00	µg/L	7.26E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.09E-07	4.52E-07	mg/kg-day	3.00E-04	mg/kg-day	1.51E-03
				Barium	2.04E+02	µg/L	3.90E-06	mg/kg-day	NA	NA	NA	2.42E-05	mg/kg-day	1.40E-02	mg/kg-day	1.73E-03
				Chromium	8.35E+00	µg/L	1.60E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	7.99E-08	9.93E-07	mg/kg-day	7.50E-05	mg/kg-day	1.32E-02
				Cobalt	1.07E+00	µg/L	8.22E-09	mg/kg-day	NA	NA	NA	5.11E-08	mg/kg-day	3.00E-04	mg/kg-day	1.70E-04
				Copper	5.22E+01	µg/L	1.00E-06	mg/kg-day	NA	NA	NA	6.22E-06	mg/kg-day	4.00E-02	mg/kg-day	1.55E-04
				Iron	8.20E+03	µg/L	1.57E-04	mg/kg-day	NA	NA	NA	9.75E-04	mg/kg-day	7.00E-01	mg/kg-day	1.39E-03
				Manganese	4.12E+02	µg/L	7.89E-06	mg/kg-day	NA	NA	NA	4.90E-05	mg/kg-day	5.60E-03	mg/kg-day	8.75E-03
				Vanadium	1.70E+01	µg/L	3.25E-07	mg/kg-day	NA	NA	NA	2.02E-06	mg/kg-day	1.82E-06	mg/kg-day	1.11E+00
			Exp. Route Total								2.35E-07					1.15E+00
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	3.30E+00	$\mu g/m^3$	NA	NA	NA	2.35E-02	mg/m^3	NA	NA	NA
				Tetrachloroethene	9.92E-01	µg/L	5.34E-02	$\mu g/m^3$	2.60E-07	$(\mu g/m^3)^{-1}$	1.39E-08	3.80E-04	mg/m^3	4.00E-02	mg/m^3	9.50E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.38E-01	$\mu g/m^3$	NA	NA	NA	9.79E-04	mg/m^3	6.00E-02	mg/m^3	1.63E-02
				Trichloroethene	5.64E-01	µg/L	1.41E-01	$\mu g/m^3$	4.10E-06	$(\mu g/m^3)^{-1}$	1.55E-11	2.27E-04	mg/m^3	2.00E-03	mg/m^3	1.14E-01
				Vinyl Chloride	7.30E-01	µg/L	1.00E+00	$\mu g/m^3$	4.40E-06	$(\mu g/m^3)^{-1}$	4.41E-06	3.28E-04	mg/m^3	1.00E-01	mg/m^3	3.28E-03
			Exp. Route Total								4.43E-06					1.43E-01
		Exposure Point Total									6.73E-05					9.20E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-7.3
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Puerto Rico Beverage	Ingestion	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	7.19E-04	mg/kg-day	NA	NA	NA	5.59E-03	mg/kg-day	1.00E+00	mg/kg-day	5.59E-03
				Arsenic	2.90E+00	mg/kg	1.60E-07	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.40E-07	1.24E-06	mg/kg-day	3.00E-04	mg/kg-day	4.14E-03
				Chromium	2.51E+01	mg/kg	1.38E-06	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	6.91E-07	1.07E-05	mg/kg-day	3.00E-03	mg/kg-day	3.58E-03
				Cobalt	6.36E+00	mg/kg	3.50E-07	mg/kg-day	NA	NA	NA	2.72E-06	mg/kg-day	3.00E-04	mg/kg-day	9.08E-03
				Iron	2.94E+04	mg/kg	1.62E-03	mg/kg-day	NA	NA	NA	1.26E-02	mg/kg-day	7.00E-01	mg/kg-day	1.80E-02
				Manganese	3.49E+02	mg/kg	1.92E-05	mg/kg-day	NA	NA	NA	1.49E-04	mg/kg-day	1.40E-01	mg/kg-day	1.07E-03
				Vanadium	5.66E+01	mg/kg	3.12E-06	mg/kg-day	NA	NA	NA	2.42E-05	mg/kg-day	7.00E-05	mg/kg-day	3.46E-01
			Exp. Route Total								9.30E-07					3.88E-01
Surface Soil	Surface Soil	Puerto Rico Beverage	Dermal Contact	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	2.90E+00	mg/kg	6.33E-09	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	9.49E-09	4.92E-08	mg/kg-day	3.00E-04	mg/kg-day	1.64E-04
				Chromium	2.51E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	6.36E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	2.94E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	3.49E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	5.66E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								9.49E-09					1.64E-04
Surface Soil	Surface Soil	Puerto Rico Beverage	Inhalation	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	1.23E-04	$\mu g/m^3$	NA	NA	NA	9.59E-07	mg/m^3	5.00E-03	mg/m^3	1.92E-04
				Arsenic	2.90E+00	mg/kg	2.74E-08	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	1.18E-10	2.13E-10	mg/m^3	1.50E-05	mg/m^3	1.42E-05
				Chromium	2.51E+01	mg/kg	2.37E-07	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	2.84E-09	1.84E-09	mg/m^3	1.00E-04	mg/m^3	1.84E-05
				Cobalt	6.36E+00	mg/kg	6.01E-08	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	5.41E-10	4.67E-10	mg/m^3	6.00E-06	mg/m^3	7.79E-05
				Iron	2.94E+04	mg/kg	2.78E-04	$\mu g/m^3$	NA	NA	NA	2.16E-06	mg/m^3	NA	NA	NA
				Manganese	3.49E+02	mg/kg	3.30E-06	$\mu g/m^3$	NA	NA	NA	2.56E-08	mg/m^3	5.00E-05	mg/m^3	5.13E-04
				Vanadium	5.66E+01	mg/kg	5.35E-07	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	4.44E-09	4.16E-09	mg/m^3	1.00E-04	mg/m^3	4.16E-05
			Exp. Route Total								7.94E-09					8.57E-04
		Exposure Point Total									9.48E-07					3.89E-01

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-7.3
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	6.00E-05	mg/kg-day	NA	NA	NA	4.67E-04	mg/kg-day	2.00E-03	mg/kg-day	2.33E-01
				Tetrachloroethene	9.92E-01	µg/L	1.09E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	2.30E-09	8.50E-06	mg/kg-day	6.00E-03	mg/kg-day	1.42E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	2.52E-06	mg/kg-day	NA	NA	NA	1.96E-05	mg/kg-day	2.00E-02	mg/kg-day	9.78E-04
				Trichloroethene	5.64E-01	µg/L	6.22E-07	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	2.86E-08	4.83E-06	mg/kg-day	5.00E-04	mg/kg-day	9.67E-03
				Vinyl Chloride	7.30E-01	µg/L	8.04E-07	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	5.79E-07	6.26E-06	mg/kg-day	3.00E-03	mg/kg-day	2.09E-03
				Inorganics												
				Aluminum	2.04E+03	µg/L	2.25E-03	mg/kg-day	NA	NA	NA	1.75E-02	mg/kg-day	1.00E+00	mg/kg-day	1.75E-02
				Arsenic	3.80E+00	µg/L	4.18E-06	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	6.27E-06	3.25E-05	mg/kg-day	3.00E-04	mg/kg-day	1.08E-01
				Barium	2.04E+02	µg/L	2.24E-04	mg/kg-day	NA	NA	NA	1.75E-03	mg/kg-day	2.00E-01	mg/kg-day	8.73E-03
				Chromium	8.35E+00	µg/L	9.20E-06	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	4.60E-06	7.16E-05	mg/kg-day	3.00E-03	mg/kg-day	2.39E-02
				Cobalt	1.07E+00	µg/L	1.18E-06	mg/kg-day	NA	NA	NA	9.21E-06	mg/kg-day	3.00E-04	mg/kg-day	3.07E-02
				Copper	5.22E+01	µg/L	5.76E-05	mg/kg-day	NA	NA	NA	4.48E-04	mg/kg-day	4.00E-02	mg/kg-day	1.12E-02
				Iron	8.20E+03	µg/L	9.03E-03	mg/kg-day	NA	NA	NA	7.03E-02	mg/kg-day	7.00E-01	mg/kg-day	1.00E-01
				Manganese	4.12E+02	µg/L	4.54E-04	mg/kg-day	NA	NA	NA	3.53E-03	mg/kg-day	1.40E-01	mg/kg-day	2.52E-02
				Vanadium	1.70E+01	µg/L	1.87E-05	mg/kg-day	NA	NA	NA	1.45E-04	mg/kg-day	7.00E-05	mg/kg-day	2.08E+00
			Exp. Route Total								1.15E-05					2.65E+00
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	8.56E-07	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	1.80E-09	6.66E-06	mg/kg-day	6.00E-03	mg/kg-day	1.11E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	2.93E-07	mg/kg-day	NA	NA	NA	2.28E-06	mg/kg-day	2.00E-02	mg/kg-day	1.14E-04
				Trichloroethene	5.64E-01	µg/L	1.41E-07	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	6.50E-09	1.10E-06	mg/kg-day	5.00E-04	mg/kg-day	2.20E-03
				Vinyl Chloride	7.30E-01	µg/L	5.49E-08	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	3.95E-08	4.27E-07	mg/kg-day	3.00E-03	mg/kg-day	1.42E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	1.01E-05	mg/kg-day	NA	NA	NA	7.86E-05	mg/kg-day	1.00E+00	mg/kg-day	7.86E-05
				Arsenic	3.80E+00	µg/L	1.88E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.82E-08	1.46E-07	mg/kg-day	3.00E-04	mg/kg-day	4.88E-04
				Barium	2.04E+02	µg/L	1.01E-06	mg/kg-day	NA	NA	NA	7.85E-06	mg/kg-day	1.40E-02	mg/kg-day	5.61E-04
				Chromium	8.35E+00	µg/L	4.14E-08	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	2.07E-08	3.22E-07	mg/kg-day	7.50E-05	mg/kg-day	4.29E-03
				Cobalt	1.07E+00	µg/L	2.13E-09	mg/kg-day	NA	NA	NA	1.66E-08	mg/kg-day	3.00E-04	mg/kg-day	5.52E-05
				Copper	5.22E+01	µg/L	2.59E-07	mg/kg-day	NA	NA	NA	2.01E-06	mg/kg-day	4.00E-02	mg/kg-day	5.04E-05
				Iron	8.20E+03	µg/L	4.06E-05	mg/kg-day	NA	NA	NA	3.16E-04	mg/kg-day	7.00E-01	mg/kg-day	4.52E-04
				Manganese	4.12E+02	µg/L	2.04E-06	mg/kg-day	NA	NA	NA	1.59E-05	mg/kg-day	5.60E-03	mg/kg-day	2.84E-03
				Vanadium	1.70E+01	µg/L	8.41E-08	mg/kg-day	NA	NA	NA	6.54E-07	mg/kg-day	1.82E-06	mg/kg-day	3.59E-01
			Exp. Route Total								9.68E-08					3.72E-01
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	1.00E+03	$\mu g/m^3$	8.05E-01	$\mu g/m^3$	NA	NA	NA	6.26E-03	mg/m^3	NA	NA	NA
				Tetrachloroethene	1.62E+01	$\mu g/m^3$	1.30E-02	$\mu g/m^3$	2.60E-07	$(\mu g/m^3)^{-1}$	3.39E-09	1.01E-04	mg/m^3	4.00E-02	mg/m^3	2.53E-03
				trans-1,2-Dichloroethene	4.18E+01	$\mu g/m^3$	3.36E-02	$\mu g/m^3$	NA	NA	NA	2.61E-04	mg/m^3	6.00E-02	mg/m^3	4.35E-03
				Trichloroethene	9.69E+00	$\mu g/m^3$	7.79E-03	$\mu g/m^3$	4.10E-06	$(\mu g/m^3)^{-1}$	3.19E-08	6.06E-05	mg/m^3	2.00E-03	mg/m^3	3.03E-02
				Vinyl Chloride	1.40E+01	$\mu g/m^3$	1.12E-02	$\mu g/m^3$	4.40E-06	$(\mu g/m^3)^{-1}$	4.95E-08	8.74E-05	mg/m^3	1.00E-01	mg/m^3	8.74E-04
			Exp. Route Total								8.48E-08					3.80E-02
		Exposure Point Total									1.17E-05					3.06E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-7.4
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Surface Soil	Surface Soil	Puerto Rico Beverage	Ingestion	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	8.29E-03	mg/kg-day	NA	NA	NA	8.34E-02	mg/kg-day	1.00E+00	mg/kg-day	8.34E-02
				Arsenic	2.90E+00	mg/kg	1.84E-06	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.77E-06	1.85E-05	mg/kg-day	3.00E-04	mg/kg-day	6.18E-02
				Chromium	2.51E+01	mg/kg	1.59E-05	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	7.97E-06	1.60E-04	mg/kg-day	3.00E-03	mg/kg-day	5.34E-02
				Cobalt	6.36E+00	mg/kg	4.04E-06	mg/kg-day	NA	NA	NA	4.06E-05	mg/kg-day	3.00E-04	mg/kg-day	1.35E-01
				Iron	2.94E+04	mg/kg	1.87E-02	mg/kg-day	NA	NA	NA	1.88E-01	mg/kg-day	7.00E-01	mg/kg-day	2.69E-01
				Manganese	3.49E+02	mg/kg	2.22E-04	mg/kg-day	NA	NA	NA	2.23E-03	mg/kg-day	1.40E-01	mg/kg-day	1.59E-02
				Vanadium	5.66E+01	mg/kg	3.60E-05	mg/kg-day	NA	NA	NA	3.62E-04	mg/kg-day	7.00E-05	mg/kg-day	5.17E+00
			Exp. Route Total								1.07E-05					5.79E+00
Surface Soil	Surface Soil	Puerto Rico Beverage	Dermal Contact	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.00E+00	mg/kg-day	NA
				Arsenic	2.90E+00	mg/kg	6.21E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	9.32E-08	6.23E-07	mg/kg-day	3.00E-04	mg/kg-day	2.08E-03
				Chromium	2.51E+01	mg/kg	NA	NA	5.00E-01	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA	7.50E-05	mg/kg-day	NA
				Cobalt	6.36E+00	mg/kg	NA	NA	NA	NA	NA	NA	NA	3.00E-04	mg/kg-day	NA
				Iron	2.94E+04	mg/kg	NA	NA	NA	NA	NA	NA	NA	7.00E-01	mg/kg-day	NA
				Manganese	3.49E+02	mg/kg	NA	NA	NA	NA	NA	NA	NA	5.60E-03	mg/kg-day	NA
				Vanadium	5.66E+01	mg/kg	NA	NA	NA	NA	NA	NA	NA	1.82E-06	mg/kg-day	NA
			Exp. Route Total								9.32E-08					2.08E-03
Surface Soil	Surface Soil	Puerto Rico Beverage	Inhalation	**Inorganics**												
				Aluminum	1.30E+04	mg/kg	1.97E-03	$\mu g/m^3$	NA	NA	NA	9.19E-06	mg/m^3	5.00E-03	mg/m^3	1.84E-03
				Arsenic	2.90E+00	mg/kg	4.38E-07	$\mu g/m^3$	4.30E-03	$(\mu g/m^3)^{-1}$	1.88E-09	2.04E-09	mg/m^3	1.50E-05	mg/m^3	1.36E-04
				Chromium	2.51E+01	mg/kg	3.79E-06	$\mu g/m^3$	1.20E-02	$(\mu g/m^3)^{-1}$	4.55E-08	1.77E-08	mg/m^3	1.00E-04	mg/m^3	1.77E-04
				Cobalt	6.36E+00	mg/kg	9.60E-07	$\mu g/m^3$	9.00E-03	$(\mu g/m^3)^{-1}$	8.64E-09	4.48E-09	mg/m^3	6.00E-06	mg/m^3	7.47E-04
				Iron	2.94E+04	mg/kg	4.45E-03	$\mu g/m^3$	NA	NA	NA	2.08E-05	mg/m^3	NA	NA	NA
				Manganese	3.49E+02	mg/kg	5.27E-05	$\mu g/m^3$	NA	NA	NA	2.46E-07	mg/m^3	5.00E-05	mg/m^3	4.92E-03
				Vanadium	5.66E+01	mg/kg	8.55E-06	$\mu g/m^3$	8.30E-03	$(\mu g/m^3)^{-1}$	7.09E-08	3.99E-08	mg/m^3	1.00E-04	mg/m^3	3.99E-04
			Exp. Route Total								1.27E-07					8.22E-03
		Exposure Point Total									1.10E-05					5.80E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-7.4
CALCULATION OF CHEMICAL CANCER RISKS AND NONCANCER HAZARDS
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	Exposure Point Concentration		Cancer Risk Calculation					Noncancer Hazard Calculation				
							Intake/ Exposure Concentration		Slope Factor/Unit Risk		Cancer	Intake/ Exposure Concentration		RfD/RfC		Hazard
					Value	Unit	Value	Unit	Value	Unit	Risk	Value	Unit	Value	Unit	Quotient
Groundwater	Groundwater	Groundwater	Ingestion	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	2.54E-04	mg/kg-day	NA	NA	NA	1.39E-03	mg/kg-day	2.00E-03	mg/kg-day	6.96E-01
				Tetrachloroethene	9.92E-01	µg/L	4.62E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	9.70E-09	2.54E-05	mg/kg-day	6.00E-03	mg/kg-day	4.23E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.06E-05	mg/kg-day	NA	NA	NA	5.84E-05	mg/kg-day	2.00E-02	mg/kg-day	2.92E-03
				Trichloroethene	5.64E-01	µg/L	1.08E-05	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	1.97E-07	1.44E-05	mg/kg-day	5.00E-04	mg/kg-day	2.88E-02
				Vinyl Chloride	7.30E-01	µg/L	2.29E-05	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	1.65E-05	1.87E-05	mg/kg-day	3.00E-03	mg/kg-day	6.22E-03
				Inorganics												
				Aluminum	2.04E+03	µg/L	9.49E-03	mg/kg-day	NA	NA	NA	5.21E-02	mg/kg-day	1.00E+00	mg/kg-day	5.21E-02
				Arsenic	3.80E+00	µg/L	1.77E-05	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	2.65E-05	9.70E-05	mg/kg-day	3.00E-04	mg/kg-day	3.23E-01
				Barium	2.04E+02	µg/L	9.48E-04	mg/kg-day	NA	NA	NA	5.21E-03	mg/kg-day	2.00E-01	mg/kg-day	2.60E-02
				Chromium	8.35E+00	µg/L	3.89E-05	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	1.94E-05	2.13E-04	mg/kg-day	3.00E-03	mg/kg-day	7.12E-02
				Cobalt	1.07E+00	µg/L	5.00E-06	mg/kg-day	NA	NA	NA	2.75E-05	mg/kg-day	3.00E-04	mg/kg-day	9.15E-02
				Copper	5.22E+01	µg/L	2.43E-04	mg/kg-day	NA	NA	NA	1.34E-03	mg/kg-day	4.00E-02	mg/kg-day	3.34E-02
				Iron	8.20E+03	µg/L	3.82E-02	mg/kg-day	NA	NA	NA	2.10E-01	mg/kg-day	7.00E-01	mg/kg-day	2.99E-01
				Manganese	4.12E+02	µg/L	1.92E-03	mg/kg-day	NA	NA	NA	1.05E-02	mg/kg-day	1.40E-01	mg/kg-day	7.53E-02
				Vanadium	1.70E+01	µg/L	7.90E-05	mg/kg-day	NA	NA	NA	4.34E-04	mg/kg-day	7.00E-05	mg/kg-day	6.20E+00
			Exp. Route Total								6.26E-05					7.91E+00
Groundwater	Groundwater	Groundwater	Dermal Contact	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	NA	NA	NA	NA	NA	NA	NA	2.00E-03	mg/kg-day	NA
				Tetrachloroethene	9.92E-01	µg/L	3.11E-06	mg/kg-day	2.10E-03	$(mg/kg\text{-}day)^{-1}$	6.53E-09	1.93E-05	mg/kg-day	6.00E-03	mg/kg-day	3.22E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.07E-06	mg/kg-day	NA	NA	NA	6.62E-06	mg/kg-day	2.00E-02	mg/kg-day	3.31E-04
				Trichloroethene	5.64E-01	µg/L	2.18E-06	mg/kg-day	4.60E-02	$(mg/kg\text{-}day)^{-1}$	3.93E-08	3.19E-06	mg/kg-day	5.00E-04	mg/kg-day	6.38E-03
				Vinyl Chloride	7.30E-01	µg/L	6.98E-15	mg/kg-day	7.20E-01	$(mg/kg\text{-}day)^{-1}$	5.03E-15	1.24E-06	mg/kg-day	3.00E-03	mg/kg-day	4.13E-04
				Inorganics												
				Aluminum	2.04E+03	µg/L	3.90E-05	mg/kg-day	NA	NA	NA	2.42E-04	mg/kg-day	1.00E+00	mg/kg-day	2.42E-04
				Arsenic	3.80E+00	µg/L	7.26E-08	mg/kg-day	1.50E+00	$(mg/kg\text{-}day)^{-1}$	1.09E-07	4.52E-07	mg/kg-day	3.00E-04	mg/kg-day	1.51E-03
				Barium	2.04E+02	µg/L	3.90E-06	mg/kg-day	NA	NA	NA	2.42E-05	mg/kg-day	1.40E-02	mg/kg-day	1.73E-03
				Chromium	8.35E+00	µg/L	1.60E-07	mg/kg-day	5.00E-01	$(mg/kg\text{-}day)^{-1}$	7.99E-08	9.93E-07	mg/kg-day	7.50E-05	mg/kg-day	1.32E-02
				Cobalt	1.07E+00	µg/L	8.22E-09	mg/kg-day	NA	NA	NA	5.11E-08	mg/kg-day	3.00E-04	mg/kg-day	1.70E-04
				Copper	5.22E+01	µg/L	1.00E-06	mg/kg-day	NA	NA	NA	6.22E-06	mg/kg-day	4.00E-02	mg/kg-day	1.55E-04
				Iron	8.20E+03	µg/L	1.57E-04	mg/kg-day	NA	NA	NA	9.75E-04	mg/kg-day	7.00E-01	mg/kg-day	1.39E-03
				Manganese	4.12E+02	µg/L	7.89E-06	mg/kg-day	NA	NA	NA	4.90E-05	mg/kg-day	5.60E-03	mg/kg-day	8.75E-03
				Vanadium	1.70E+01	µg/L	3.25E-07	mg/kg-day	NA	NA	NA	2.02E-06	mg/kg-day	1.82E-06	mg/kg-day	1.11E+00
			Exp. Route Total								2.35E-07					1.15E+00
Groundwater	Groundwater	Groundwater	Inhalation	**Volatile Organic Compounds**												
				cis-1,2-Dichloroethene	5.45E+01	µg/L	3.30E+00	$\mu g/m^3$	NA	NA	NA	2.35E-02	mg/m^3	NA	NA	NA
				Tetrachloroethene	9.92E-01	µg/L	5.34E-02	$\mu g/m^3$	2.60E-07	$(\mu g/m^3)^{-1}$	1.39E-08	3.80E-04	mg/m^3	4.00E-02	mg/m^3	9.50E-03
				trans-1,2-Dichloroethene	2.28E+00	µg/L	1.38E-01	$\mu g/m^3$	NA	NA	NA	9.79E-04	mg/m^3	6.00E-02	mg/m^3	1.63E-02
				Trichloroethene	5.64E-01	µg/L	1.41E-01	$\mu g/m^3$	4.10E-06	$(\mu g/m^3)^{-1}$	1.55E-11	2.27E-04	mg/m^3	2.00E-03	mg/m^3	1.14E-01
				Vinyl Chloride	7.30E-01	µg/L	1.00E+00	$\mu g/m^3$	4.40E-06	$(\mu g/m^3)^{-1}$	4.41E-06	3.28E-04	mg/m^3	1.00E-01	mg/m^3	3.28E-03
			Exp. Route Total								4.43E-06					1.43E-01
		Exposure Point Total									6.73E-05					9.20E+00

NA = not applicable
RfD = reference dose
mg/kg = milligram per kilogram
mg/kg-day = milligram per kilogram per day
$\mu g/m^3$ = microgram per cubic meter
mg/m^3 = milligram per cubic meter

TABLE F-9.1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	3E-08	5E-09	7E-13	3E-08	NA	NA	NA	NA	NA
			Dibenzo(a,h)anthracene	7E-09	1E-09	2E-13	8E-09	NA	NA	NA	NA	NA
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	6E-03	NA	2E-04	6E-03
			Arsenic	3E-07	1E-08	1E-10	3E-07	Skin/Developmental/ Cardiovascular System/CNS/Lung	5E-03	2E-04	2E-05	5E-03
			Chromium	4E-07	NA	2E-09	4E-07	Lung	2E-03	NA	1E-05	2E-03
			Cobalt	NA	NA	7E-10	7E-10	Thyroid/Respiratory System/Lung	1E-02	NA	1E-04	1E-02
			Iron	NA	NA	NA	NA	GI Tract	2E-02	NA	NA	2E-02
			Manganese	NA	NA	NA	NA	CNS	1E-03	NA	7E-04	2E-03
			Vanadium	NA	NA	5E-09	5E-09	Kidney/Respiratory System	4E-01	NA	5E-05	4E-01
			Chemical Total	7E-07	2E-08	8E-09	8E-07	Chemical Total	4E-01	2E-04	1E-03	4E-01
		Exposure Point Total					8E-07					4E-01
	Exposure Medium Total						8E-07					4E-01
Medium Total							8E-07					4E-01

TABLE F-9.1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	2E-01	NA	NA	2E-01
			Tetrachloroethene	2E-09	2E-09	3E-09	7E-09	Liver	1E-03	1E-03	3E-03	5E-03
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	1E-03	1E-04	4E-03	5E-03
			Trichloroethene	3E-08	6E-09	3E-08	7E-08	Heart/ Immunogical/ Developmental/Kidney	1E-02	2E-03	3E-02	4E-02
			Vinyl Chloride	6E-07	4E-08	5E-08	7E-07	Liver	2E-03	1E-04	9E-04	3E-03
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	2E-02	8E-05	NA	2E-02
			Arsenic	6E-06	3E-08	NA	6E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	5E-04	NA	1E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	9E-03	6E-04	NA	9E-03
			Chromium	5E-06	2E-08	NA	5E-06	Lung	2E-02	4E-03	NA	3E-02
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	3E-02	6E-05	NA	3E-02
			Copper	NA	NA	NA	NA	GI Tract	1E-02	5E-05	NA	1E-02
			Iron	NA	NA	NA	NA	GI Tract	1E-01	5E-04	NA	1E-01
			Manganese	NA	NA	NA	NA	CNS	3E-02	3E-03	NA	3E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	4E-01	NA	2E+00
			Chemical Total	1E-05	1E-07	8E-08	1E-05	Chemical Total	3E+00	4E-01	4E-02	3E+00
		Exposure Point Total					1E-05					3E+00
	Exposure Medium Total						1E-05					3E+00
Medium Total							1E-05					3E+00
Receptor Total							1E-05					4E+00

Total Excess Cancer Risk Across All Media	1E-05	Total Hazard Index Across All Media	4

Blood HI Across All Media =	<0.01
Liver HI Across All Media =	0.01
Kidney HI Across All Media =	3
CNS HI Across All Media =	0.1
Development HI Across All Media =	0.2
Respiratory System HI Across All Media =	3
Lung HI Across All Media =	0.2
Cardiovascular System HI Across All Media =	0.1
Skin HI Across All Media =	0.1
Heart HI Across All Media =	0.04
GI Tract HI Across All Media =	0.1
Fetus HI Across All Media =	<0.01

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE F-9.2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	2E-06	2E-07	6E-11	2E-06	NA	NA	NA	NA	NA
			Dibenzo(a,h)anthracene	4E-07	6E-08	2E-11	5E-07	NA	NA	NA	NA	NA
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	9E-02	NA	2E-03	9E-02
			Arsenic	3E-06	1E-07	2E-09	4E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	8E-02	3E-03	2E-04	8E-02
			Chromium	5E-06	NA	3E-08	5E-06	Lung	3E-02	NA	1E-04	3E-02
			Cobalt	NA	NA	1E-08	1E-08	Thyroid/Respiratory System/Lung	2E-01	NA	1E-03	2E-01
			Iron	NA	NA	NA	NA	GI Tract	3E-01	NA	NA	3E-01
			Lead					NA				
			Manganese	NA	NA	NA	NA	CNS	2E-02	NA	7E-03	3E-02
			Vanadium	NA	NA	8E-08	8E-08	Kidney/Respiratory System	6E+00	NA	4E-04	6E+00
			Chemical Total	1E-05	4E-07	1E-07	1E-05	Chemical Total	7E+00	3E-03	1E-02	7E+00
		Exposure Point Total					1E-05					7E+00
	Exposure Medium Total						1E-05					7E+00
Medium Total							1E-05					7E+00

TABLE F-9.2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	7E-01	NA	NA	7E-01
			Tetrachloroethene	1E-08	7E-09	1E-08	3E-08	Liver	4E-03	3E-03	9E-03	2E-02
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	3E-03	3E-04	2E-02	2E-02
			Trichloroethene	2E-07	4E-08	2E-11	2E-07	Heart/ Immunogical/ Developmental/Kidney	3E-02	6E-03	1E-01	1E-01
			Vinyl Chloride	2E-05	5E-15	4E-06	2E-05	Liver	6E-03	4E-04	3E-03	1E-02
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	5E-02	2E-04	NA	5E-02
			Arsenic	3E-05	1E-07	NA	3E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	3E-01	2E-03	NA	3E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	3E-02	2E-03	NA	3E-02
			Chromium	2E-05	8E-08	NA	2E-05	Lung	7E-02	1E-02	NA	8E-02
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	9E-02	2E-04	NA	9E-02
			Copper	NA	NA	NA	NA	GI Tract	3E-02	2E-04	NA	3E-02
			Iron	NA	NA	NA	NA	GI Tract	3E-01	1E-03	NA	3E-01
			Manganese	NA	NA	NA	NA	CNS	8E-02	9E-03	NA	8E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	6E+00	1E+00	NA	7E+00
			Chemical Total	6E-05	2E-07	4E-06	7E-05	Chemical Total	8E+00	1E+00	1E-01	9E+00
		Exposure Point Total					7E-05					9E+00
	Exposure Medium Total						7E-05					9E+00
Medium Total							7E-05					9E+00
Receptor Total							8E-05					2E+01

Total Excess Cancer Risk Across All Media	8E-05
Total Hazard Index Across All Media	16

Blood HI Across All Media =	0.02
Liver HI Across All Media =	0.05
Kidney HI Across All Media =	14
CNS HI Across All Media =	0.5
Development HI Across All Media =	0.6
Respiratory System HI Across All Media =	13
Lung HI Across All Media =	0.8
Cardiovascular System HI Across All Media =	0.4
Skin HI Across All Media =	0.4
Heart HI Across All Media =	0.1
GI Tract HI Across All Media =	0.7
Fetus HI Across All Media =	0.03

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE F-9.3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Aluminum	NA	NA	NA	NA	Neurological	6E-03	NA	2E-04	6E-03
			Arsenic	2E-07	9E-09	1E-10	2E-07	Skin/Developmental/ Cardiovascular System/CNS/Lung	4E-03	2E-04	1E-05	4E-03
			Chromium	7E-07	NA	3E-09	7E-07	Lung	4E-03	NA	2E-05	4E-03
			Cobalt	NA	NA	5E-10	5E-10	Thyroid/Respiratory System/Lung	9E-03	NA	8E-05	9E-03
			Iron	NA	NA	NA	NA	GI Tract	2E-02	NA	NA	2E-02
			Manganese	NA	NA	NA	NA	CNS	1E-03	NA	5E-04	2E-03
			Vanadium	NA	NA	4E-09	4E-09	Kidney/Respiratory System	3E-01	NA	4E-05	3E-01
			Chemical Total	9E-07	9E-09	8E-09	9E-07	Chemical Total	4E-01	2E-04	9E-04	4E-01
		Exposure Point Total					9E-07					4E-01
	Exposure Medium Total						9E-07					4E-01
Medium Total							9E-07					4E-01

TABLE F-9.3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	2E-01	NA	NA	2E-01
			Tetrachloroethene	2E-09	2E-09	3E-09	7E-09	Liver	1E-03	1E-03	3E-03	5E-03
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	1E-03	1E-04	4E-03	5E-03
			Trichloroethene	3E-08	6E-09	3E-08	7E-08	Heart/ Immunogical/ Developmental/Kidney	1E-02	2E-03	3E-02	4E-02
			Vinyl Chloride	6E-07	4E-08	5E-08	7E-07	Liver	2E-03	1E-04	9E-04	3E-03
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	2E-02	8E-05	NA	2E-02
			Arsenic	6E-06	3E-08	NA	6E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	5E-04	NA	1E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	9E-03	6E-04	NA	9E-03
			Chromium	5E-06	2E-08	NA	5E-06	Lung	2E-02	4E-03	NA	3E-02
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	3E-02	6E-05	NA	3E-02
			Copper	NA	NA	NA	NA	GI Tract	1E-02	5E-05	NA	1E-02
			Iron	NA	NA	NA	NA	GI Tract	1E-01	5E-04	NA	1E-01
			Manganese	NA	NA	NA	NA	CNS	3E-02	3E-03	NA	3E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	4E-01	NA	2E+00
			Chemical Total	1E-05	1E-07	8E-08	1E-05	Chemical Total	3E+00	4E-01	4E-02	3E+00
		Exposure Point Total					1E-05					3E+00
	Exposure Medium Total						1E-05					3E+00
Medium Total							1E-05					3E+00
Receptor Total							1E-05					3E+00

Total Excess Cancer Risk Across All Media	1E-05
Total Hazard Index Across All Media	3

Blood HI Across All Media =	<0.01
Liver HI Across All Media =	0.01
Kidney HI Across All Media =	3
CNS HI Across All Media =	0.1
Development HI Across All Media =	0.2
Respiratory System HI Across All Media =	3
Lung HI Across All Media =	0.2
Cardiovascular System HI Across All Media =	0.1
Skin HI Across All Media =	0.1
Heart HI Across All Media =	0.04
GI Tract HI Across All Media =	0.1
Fetus HI Across All Media =	<0.01

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE F-9.4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Aluminum	NA	NA	NA	NA	Neurological	8E-02	NA	2E-03	9E-02
			Arsenic	3E-06	9E-08	2E-09	3E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	6E-02	2E-03	1E-04	6E-02
			Chromium	8E-06	NA	5E-08	8E-06	Lung	5E-02	NA	2E-04	5E-02
			Cobalt	NA	NA	9E-09	9E-09	Thyroid/Respiratory System/Lung	1E-01	NA	7E-04	1E-01
			Iron	NA	NA	NA	NA	GI Tract	3E-01	NA	NA	3E-01
			Manganese	NA	NA	NA	NA	CNS	2E-02	NA	5E-03	2E-02
			Vanadium	NA	NA	7E-08	7E-08	Kidney/Respiratory System	5E+00	NA	4E-04	5E+00
			Chemical Total	1E-05	9E-08	1E-07	1E-05	Chemical Total	6E+00	2E-03	8E-03	6E+00
		Exposure Point Total					1E-05					6E+00
	Exposure Medium Total						1E-05					6E+00
Medium Total							1E-05					6E+00

TABLE F-9.4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			cis-1,2-Dichloroethene	NA	NA	NA	NA	Kidney	7E-01	NA	NA	7E-01
			Tetrachloroethene	1E-08	7E-09	1E-08	3E-08	Liver	4E-03	3E-03	9E-03	2E-02
			trans-1,2-Dichloroethene	NA	NA	NA	NA	Blood/Lung/Liver	3E-03	3E-04	2E-02	2E-02
			Trichloroethene	2E-07	4E-08	2E-11	2E-07	Heart/ Immunogical/ Developmental/Kidney	3E-02	6E-03	1E-01	1E-01
			Vinyl Chloride	2E-05	5E-15	4E-06	2E-05	Liver	6E-03	4E-04	3E-03	1E-02
			Inorganics									
			Aluminum	NA	NA	NA	NA	Neurological	5E-02	2E-04	NA	5E-02
			Arsenic	3E-05	1E-07	NA	3E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	3E-01	2E-03	NA	3E-01
			Barium	NA	NA	NA	NA	Kidney/Fetus	3E-02	2E-03	NA	3E-02
			Chromium	2E-05	8E-08	NA	2E-05	Lung	7E-02	1E-02	NA	8E-02
			Cobalt	NA	NA	NA	NA	Thyroid/Respiratory System/Lung	9E-02	2E-04	NA	9E-02
			Copper	NA	NA	NA	NA	GI Tract	3E-02	2E-04	NA	3E-02
			Iron	NA	NA	NA	NA	GI Tract	3E-01	1E-03	NA	3E-01
			Manganese	NA	NA	NA	NA	CNS	8E-02	9E-03	NA	8E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	6E+00	1E+00	NA	7E+00
			Chemical Total	6E-05	2E-07	4E-06	7E-05	Chemical Total	8E+00	1E+00	1E-01	9E+00
		Exposure Point Total					7E-05					9E+00
	Exposure Medium Total						7E-05					9E+00
Medium Total							7E-05					9E+00
Receptor Total							8E-05					1E+01

Total Excess Cancer Risk Across All Media	8E-05
Total Hazard Index Across All Media	15

Blood HI Across All Media =	0.02
Liver HI Across All Media =	0.05
Kidney HI Across All Media =	13
CNS HI Across All Media =	0.5
Development HI Across All Media =	0.5
Respiratory System HI Across All Media =	13
Lung HI Across All Media =	0.8
Cardiovascular System HI Across All Media =	0.4
Skin HI Across All Media =	0.4
Heart HI Across All Media =	0.1
GI Tract HI Across All Media =	0.6
Fetus HI Across All Media =	0.03

NA = not applicable CNS = central nervous system GI = gastrointestinal

TABLE F-10.1
RISK ASSESSMENT SUMMARY
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	Chemical Total	7E-07	2E-08	8E-09	8E-07	Chemical Total	4E-01	2E-04	1E-03	4E-01
		Exposure Point Total					8E-07					4E-01
	Exposure Medium Total						8E-07					4E-01
Medium Total							8E-07					4E-01
Groundwater	Groundwater	Groundwater	**Inorganics**									
			Arsenic	6E-06	3E-08	NA	6E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	5E-04	NA	1E-01
			Chromium	5E-06	2E-08	NA	5E-06	Lung	2E-02	4E-03	NA	3E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	4E-01	NA	2E+00
			Chemical Total	1E-05	1E-07	8E-08	1E-05	Chemical Total	3E+00	4E-01	4E-02	3E+00
		Exposure Point Total					1E-05					3E+00
	Exposure Medium Total						1E-05					3E+00
Medium Total							1E-05					3E+00
Receptor Total							1E-05					4E+00

Total Excess Cancer Risk Across All Media	1E-05	Total Hazard Index Across All Media	4
		Kidney HI Across All Media =	3
		Respiratory System HI Across All Media =	3

NA = not applicable CNS = central nervous system GI = gastrointestinal
Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE F-10.2
RISK ASSESSMENT SUMMARY
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Former Sugar Mill	**Semi-volatile Organic Compounds**									
			Benzo(a)pyrene	2E-06	2E-07	6E-11	2E-06	NA	NA	NA	NA	NA
			Inorganics									
			Arsenic	3E-06	1E-07	2E-09	4E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	8E-02	3E-03	2E-04	8E-02
			Chromium	5E-06	NA	3E-08	5E-06	Lung	3E-02	NA	1E-04	3E-02
			Vanadium	NA	NA	8E-08	8E-08	Kidney/Respiratory System	6E+00	NA	4E-04	6E+00
			Chemical Total	1E-05	4E-07	1E-07	1E-05	Chemical Total	7E+00	3E-03	1E-02	7E+00
		Exposure Point Total					1E-05					7E+00
	Exposure Medium Total						1E-05					7E+00
Medium Total							1E-05					7E+00
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			Vinyl Chloride	2E-05	5E-15	4E-06	2E-05	Liver	6E-03	4E-04	3E-03	1E-02
			Inorganics									
			Arsenic	3E-05	1E-07	NA	3E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	3E-01	2E-03	NA	3E-01
			Chromium	2E-05	8E-08	NA	2E-05	Lung	7E-02	1E-02	NA	8E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	6E+00	1E+00	NA	7E+00
			Chemical Total	6E-05	2E-07	4E-06	7E-05	Chemical Total	8E+00	1E+00	1E-01	9E+00
		Exposure Point Total					7E-05					9E+00
	Exposure Medium Total						7E-05					9E+00
Medium Total							7E-05					9E+00
Receptor Total							8E-05					2E+01

Total Excess Cancer Risk Across All Media: 8E-05

Total Hazard Index Across All Media: 16

Kidney HI Across All Media = 14

Respiratory System HI Across All Media = 13

NA = not applicable CNS = central nervous system GI = gastrointestinal

Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE F-10.3
RISK ASSESSMENT SUMMARY
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Current/Future
Receptor Population:	Commercial/Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	Chemical Total	9E-07	9E-09	8E-09	9E-07	Chemical Total	4E-01	2E-04	9E-04	4E-01
		Exposure Point Total					9E-07					4E-01
	Exposure Medium Total						9E-07					4E-01
Medium Total							9E-07					4E-01
Groundwater	Groundwater	Groundwater	**Inorganics**									
			Arsenic	6E-06	3E-08	NA	6E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	1E-01	5E-04	NA	1E-01
			Chromium	5E-06	2E-08	NA	5E-06	Lung	2E-02	4E-03	NA	3E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	2E+00	4E-01	NA	2E+00
			Chemical Total	1E-05	1E-07	8E-08	1E-05	Chemical Total	3E+00	4E-01	4E-02	3E+00
		Exposure Point Total					1E-05					3E+00
	Exposure Medium Total						1E-05					3E+00
Medium Total							1E-05					3E+00
Receptor Total							1E-05					3E+00

Total Excess Cancer Risk Across All Media	1E-05
Total Hazard Index Across All Media	3
Kidney HI Across All Media =	3
Respiratory System HI Across All Media =	3

NA = not applicable CNS = central nervous system GI = gastrointestinal
Note:
Only chemicals above EPA's threshold values are listed in this table

TABLE F-10.4
RISK ASSESSMENT SUMMARY
CENTRAL TENDENCY EXPOSURE
Maunabo Groundwater Contamination Site
Maunabo, Puerto Rico

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Lifetime

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk				Noncancer Hazard Quotient				
				Ingestion	Dermal Contact	Inhalation	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal Contact	Inhalation	Exposure Routes Total
Surface Soil	Surface Soil	Puerto Rico Beverage	**Inorganics**									
			Arsenic	3E-06	9E-08	2E-09	3E-06	Skin/Developmental/ Cardiovascular System/CNS/Lung	6E-02	2E-03	1E-04	6E-02
			Chromium	8E-06	NA	5E-08	8E-06	Lung	5E-02	NA	2E-04	5E-02
			Vanadium	NA	NA	7E-08	7E-08	Kidney/Respiratory System	5E+00	NA	4E-04	5E+00
			Chemical Total	1E-05	9E-08	1E-07	1E-05	Chemical Total	6E+00	2E-03	8E-03	6E+00
		Exposure Point Total					1E-05					6E+00
	Exposure Medium Total						1E-05					6E+00
Medium Total							1E-05					6E+00
Groundwater	Groundwater	Groundwater	**Volatile Organic Compounds**									
			Vinyl Chloride	2E-05	5E-15	4E-06	2E-05	Liver	6E-03	4E-04	3E-03	1E-02
			Inorganics									
			Arsenic	3E-05	1E-07	NA	3E-05	Skin/Developmental/ Cardiovascular System/CNS/Lung	3E-01	2E-03	NA	3E-01
			Chromium	2E-05	8E-08	NA	2E-05	Lung	7E-02	1E-02	NA	8E-02
			Vanadium	NA	NA	NA	NA	Kidney/Respiratory System	6E+00	1E+00	NA	7E+00
			Chemical Total	6E-05	2E-07	4E-06	7E-05	Chemical Total	8E+00	1E+00	1E-01	9E+00
		Exposure Point Total					7E-05					9E+00
	Exposure Medium Total						7E-05					9E+00
Medium Total							7E-05					9E+00
Receptor Total							8E-05					1E+01

Total Excess Cancer Risk Across All Media	8E-05
Total Hazard Index Across All Media	15
Kidney HI Across All Media =	13
Respiratory System HI Across All Media =	13

NA = not applicable CNS = central nervous system GI = gastrointestinal
Note:
Only chemicals above EPA's threshold values are listed in this table